The organization of this document is largely based on the general categories proposed by the "Montreal Process"[2], with some modifications. The overall purpose of the document is to describe the physical, biological and sociological attributes of one ecoregion in Massachusetts, and to develop a set of land management goals, objectives and guidelines that will serve as a framework for the subsequent development of land management plans for individual properties within that ecoregion. The document is organized into two main sections: the "descriptive" portion of the document includes subsections on Conservation of Biological Diversity; Forest Conditions, Health and Productivity; Soil & Water Conservation; Regional and Global Considerations; and Socio-economic Factors. The second section addresses Issues, Goals and Recommendations; and Infrastructure and Resource Needs. The data and other information used in this document come from a variety of sources, but much of it originated from the Massachusetts Geographic Information Systems (MassGIS) office.

II. The Setting

Fifteen ecoregions are being proposed for Massachusetts (Figure 1), representing a "hybrid" of the regions used by EPA and the USFS. The proposed regions range in size from approximately 127 square miles (the Taconic Mountains Ecoregion) to more than 1600 square miles (the Gulf of Maine Coastal Plain ecoregion) (Table 1).

Table 1. Information on Massachusetts ecoregions.

Ecoregion Name	Acres	% of Total	Sq.Mi.
Taconic Mountains	81482	1.6%	127.3
W. New England Marble Valleys	215700	4.2%	337.0
Vermont Piedmont	94328	1.8%	147.4
SE New England Coastal Hills & Plains	233904	4.5%	365.5
Narragansett-Bristol Lowlands	586519	11.3%	916.4
Lower Worcester Plateau	681632	13.2%	1065.1
Lower Berkshire Hills	172995	3.3%	270.3
Gulf of Maine Coastal Plain	1024310	19.8%	1600.5
Gulf of Maine Coastal Lowland	186697	3.6%	291.7
Boston Basin	204211	3.9%	319.1
Berkshire Transition	229489	4.4%	358.6
Cape Cod Coastal Lowland and Islands	517663	10.0%	808.8
Connecticut River Valley	354497	6.8%	553.9
Green Mountains - Berkshire Highlands	306541	5.9%	479.0
Worcester - Monadnock Plateau	289006	5.6%	451.6
Totals	5178974	100.0%	8092.1

The Lower Worcester Plateau (LWP) ecoregion covers approximately 681,600 acres in west-central Massachusetts (Figure 2). It's the second largest ecoregion in the state, comprising 13.2% of the total land area of Massachusetts. The LWP ecoregion includes part (n=27) or all (n=24) of 51 communities (48 towns, 3 cities) in 5 counties and 7 major river basins (Figures 3-5).

The LWP ecoregion is in the Eastern Broadleaf Forest Province and the Lower New England Section of the USFS ecoregion classification system (Bailey 1995). Landforms in this Province are mostly hilly, with elevations ranging from sea level to about 1000 feet, with occasional higher monadnocks. The continental climate regime ensures a strong annual temperature cycle, with cold

[2] The Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests ("Montreal Process") is a group of nations, international organizations and non-governmental organizations formed in 1994 to advance the conservation and sustainable management of temperate and boreal forests. In 1995, 11 countries endorsed a comprehensive set of criteria and indicators to achieve those goals for use by their respective policy-makers.

winters and warm summers. There is year-round precipitation, which is markedly greater in summer months. The Province is characterized by a temperate deciduous forest, dominated by tall broadleaf trees that provide a dense continuous canopy in summer and shed their leaves completely in winter.

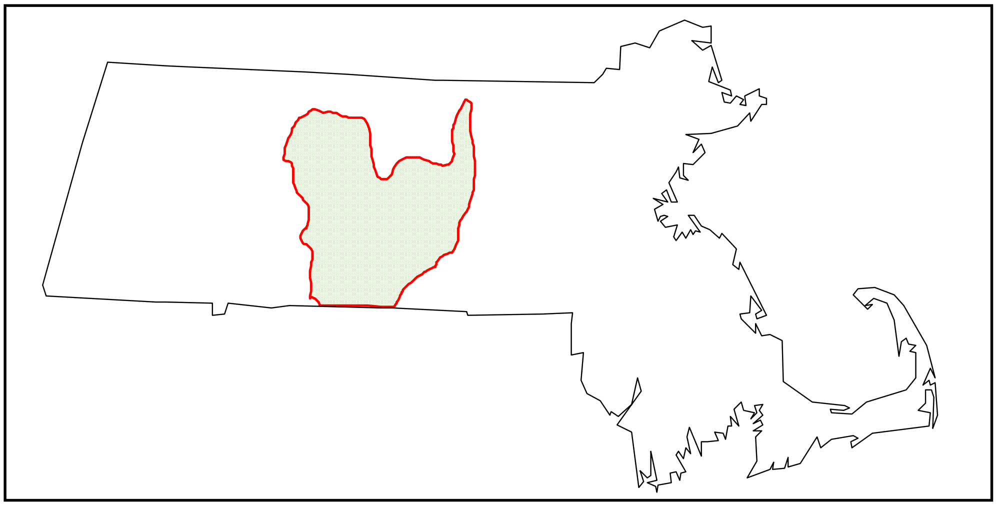

Figure 2. Location of the Lower Worcester Plateau ecoregion in central Massachusetts

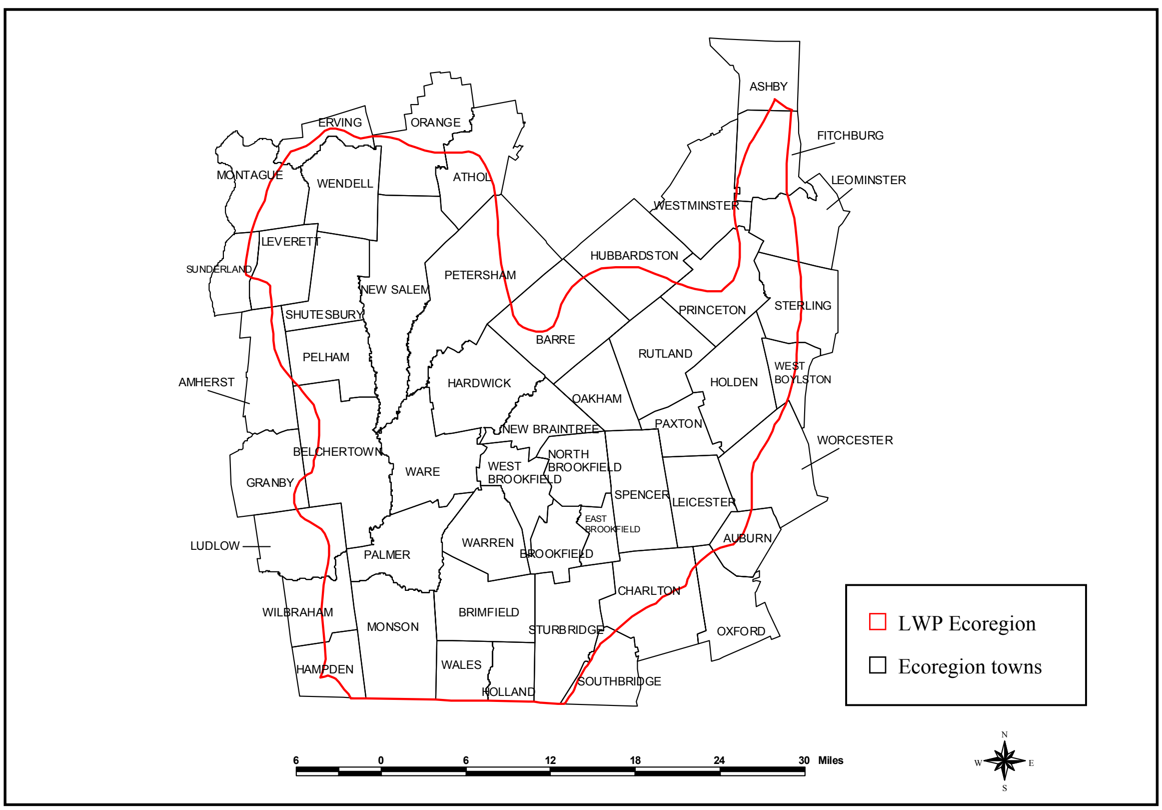

Figure 3. Communities in the Lower Worcester Plateau ecoregion.

Lower layers of small trees and shrubs develop weakly. In spring, a luxuriant ground cover of herbs quickly develops, but is greatly reduced after trees reach full foliage and shade the ground. Soils are characteristically Alfisols, and in deciduous forest areas, a thick layer of leaves covers the ground and humus is abundant.

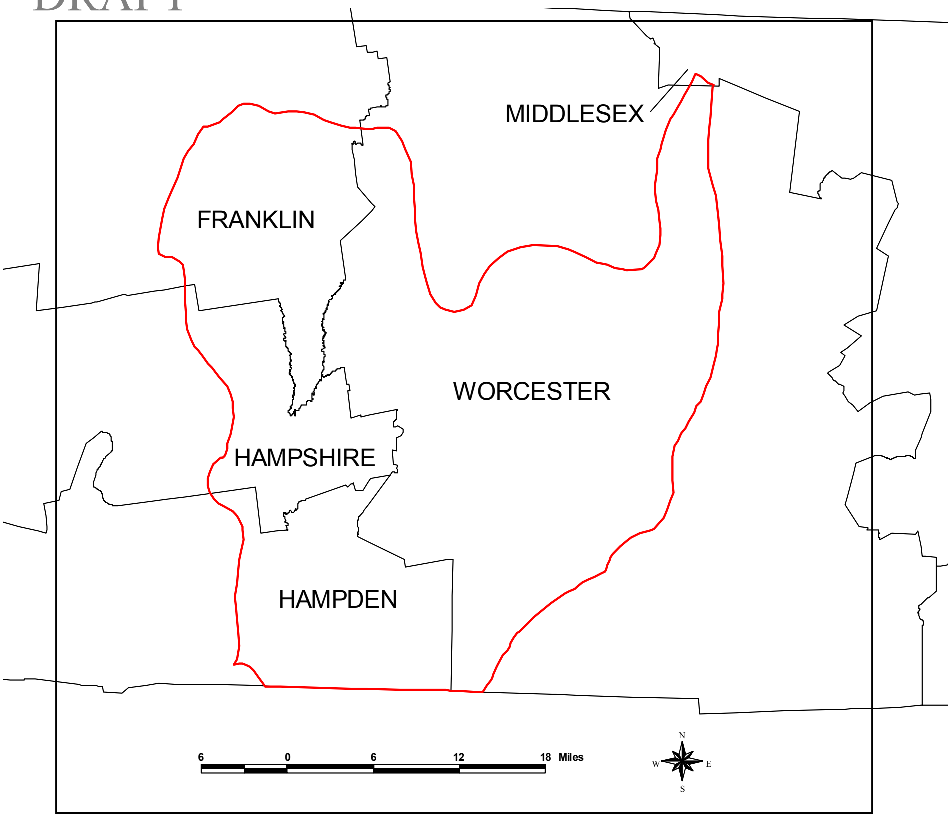

Figure 4. Counties in the Lower Worcester Plateau ecoregion.

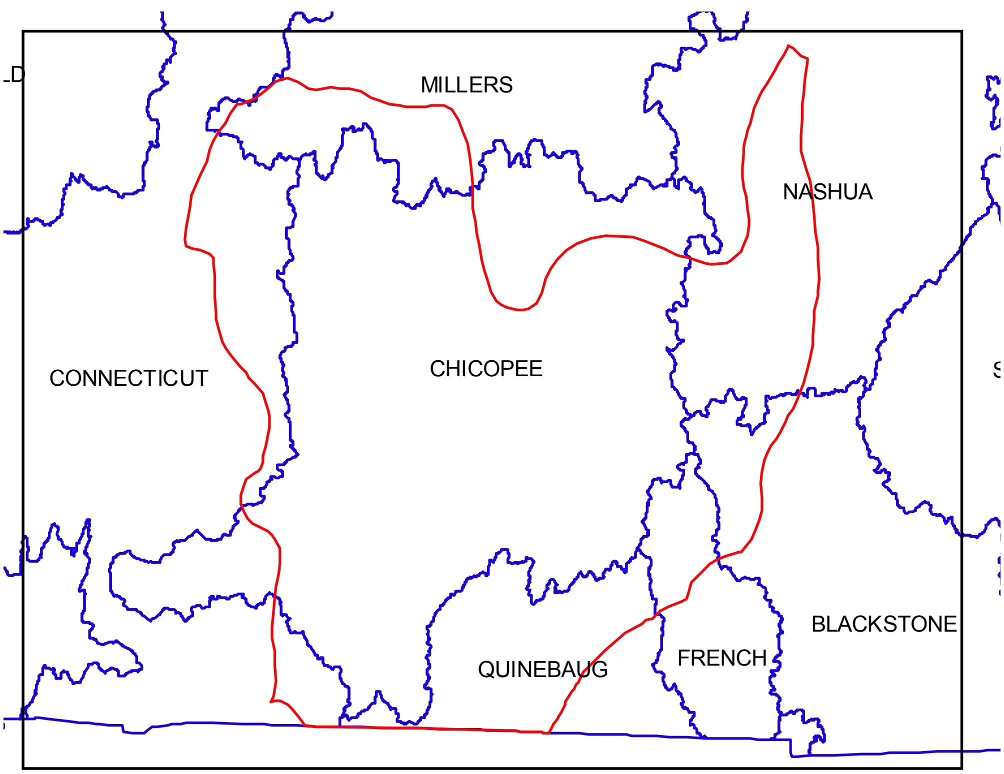

Figure 5. Major river basins in the Lower Worcester Plateau ecoregion.

The Lower New England Section is characterized by northern hardwoods and northeastern oak-pine vegetation types. The growing season generally ranges from 120-180 days. Water resources are abundant, with generally low (but locally steep) stream gradients. Disturbance regimes in the region include intermediate to high occurrences of fire and hurricane winds. Modern forest characteristics are strongly influenced by land use, particularly agricultural use dating from colonial times and subsequent farm abandonment. A number of insect and disease disturbances also affect the forest in this Section, which dominates approximately 70% of the land area.

The Worcester/Monadnock Plateau Subsection (i.e., the Lower Worcester Plateau ecoregion in this document) is considered a glaciated plain, with open high hills and elevations ranging from 100-1400 feet. Soil types include Wisconsinan sandy till with sand/gravel/silt deposits in the valleys, and areas of Paleozoic intrusives and schist/granite/gneiss. Precipitation averages 44 inches per year with a mean annual temperature of 48^{o}F and a 156 day growing season. There are many small lakes in the region, one large man-made one (Quabbin Reservoir), and many narrow-valley streams. Potential vegetation types in this subsection include hemlock-white pine-oak, maple-birch-beech, and red oak-hardwood mesic forests.

The LWP ecoregion is still largely rural, with almost 73% of its land area classified as forest. Just over 12% of the ecoregion was "developed" as of 1999, with lesser amounts in agriculture/open and in water/wetlands (Table 2 and Figure 6).

Table 2. Landuse in the Lower Worcester Plateau ecoregion, 1985 and 1999.

	1985		1999		1985-1999
Landuse	**Acres**	**%**	**Acres**	**%**	**% change**
Ag/Open	66,540.0	9.76%	60,205.0	8.83%	-9.52%
Forest	509,258.3	74.71%	497,466.9	72.98%	-2.32%
Developed	66,511.1	9.76%	84,645.0	12.42%	27.26%
Water/Wet	39,322.0	5.77%	39,316.1	5.77%	-0.02%
Totals:	681,631.4	100.00%	681,633.0	100.00%	

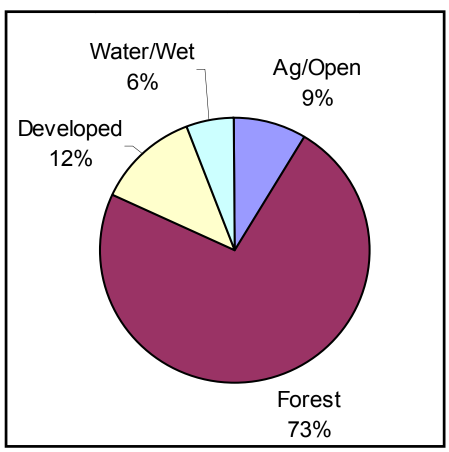

Figure 6. Landuse in the Lower Worcester Plateau ecoregion, 1999.

III. Conservation of Biological Diversity

Massachusetts has a rich diversity of natural resources. However, throughout the state, biodiversity is being threatened by the destruction and fragmentation of habitat (NHESP 2001). Several state initiatives are attempting to combat this trend. Chief among these are the efforts of EOEA agencies, private conservation organizations, and local governments to identify and protect important open space.

Protected Open Space and Land Conservation

Presently, approximately 37% (almost 253,000 acres) of the Lower Worcester Plateau ecoregion is considered "protected open space" (Figure 7). About 72% of this is considered permanently protected; the remainder has limited or temporary protection (e.g., classified lands under Chapter 61, 61A or 61B, etc.). Most of the protected open space in the ecoregion is state-owned (53% of total), with lesser amounts owned by local governments (9.4%) and non-governmental organizations (5.8%). The federal government owns relatively little land in the ecoregion (about 1300 acres, or 0.5%). Ownership of protected lands is summarized in Table 3.

The Statewide Land Conservation Plan (SLCP) identifies an additional 124,207 acres of lands that are considered high priority for protection. The Plan is a twenty year/one million acre land conservation vision, created in partnership by land trusts and other environmental non-profits, state, federal and regional environmental agencies and municipalities. The Plan is a grassroots "greenprint" to create a connected open space network across the state before the most significant and connected water supply, biodiversity, urban open spaces, working farms and forests and future recreational sites are lost forever. In developing the plan, more than 40 statewide, regional and local natural resource and open space plans were used to map the most critical statewide and regional resources. The implementation of the plan will involve a range of land conservation and planning tools to protect the most critical resources in the state.

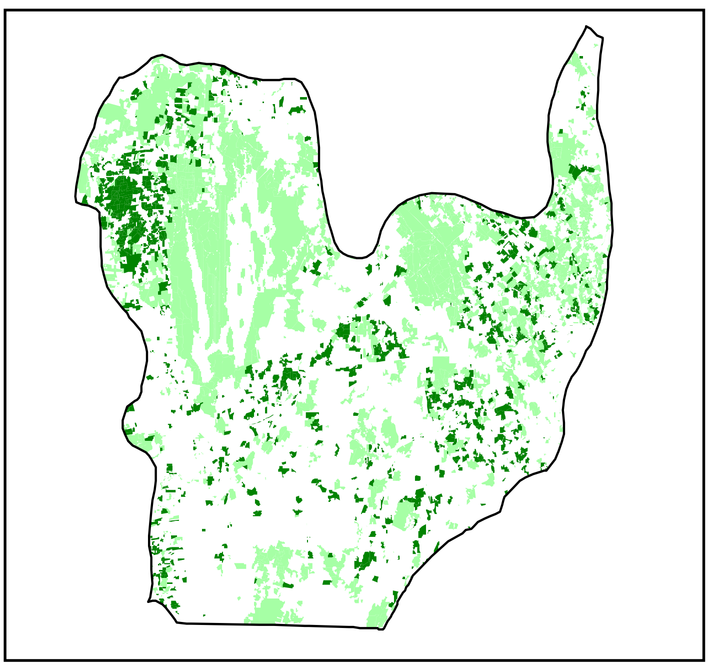

Figure 7. Permanently (lighter color) and temporarily (darker color) protected open space in the Lower Worcester Plateau ecoregion.

Table 3. Protected open space[1] in the Lower Worcester Plateau ecoregion.

Type	Acres	% of Ecoregion	% of protected land
Federal	**1,338.17**	**0.20%**	**0.53%**
State	**133,809.91**	**19.63%**	**52.92%**
DCR-DSPR	*26,147.29*	*3.84%*	*10.34%*
DCR-DWSP	*86,882.75*	*12.75%*	*34.36%*
DFW	*18,247.30*	*2.68%*	*7.22%*
Other	*2,532.57*	*0.37%*	*1.00%*
Local Govt	**23,667.05**	**3.47%**	**9.36%**
County	*202.16*	*0.03%*	*0.08%*
Municipal	*23,464.89*	*3.44%*	*9.28%*
NGO	**14,598.19**	**2.14%**	**5.77%**
Private[2]	**21,566.60**	**3.16%**	**8.53%**
Classified Land[3]	**51,894.42**	**7.61%**	**20.52%**
Chapter 61	*24,073.49*	*3.53%*	*9.52%*
Chapter 61A	*19,944.04*	*2.93%*	*7.89%*
Chapter 61B	*7,876.89*	*1.16%*	*3.12%*
Other	**5,977.94**	**0.88%**	**2.36%**
Totals:	**252,852.28**	**37.10%**	**100.00%**

[1] The lands included in this table are under various levels of protection. Most state and federal government land is permanently protected; local government lands somewhat less so; Some NGO lands have permanent protection while others do not; classified land is temporarily protected.
[2] Private protected lands include Conservation Restrictions (CRs) and Agricultural Preservation Restrictions (APRs)
[3]Acreages of classified lands are incomplete, since accurate data has not yet been included in MassGIS data layers for all towns in the ecoregion.

One of the underlying goals of the SLCP and of EOEA's land conservation strategy in general is the protection of lands considered to be of high importance from a biodiversity conservation standpoint. The BioMap project (NHESP 2001) provided a "blueprint" of biodiversity hotspots in the state – i.e., *the most important intact terrestrial and wetland ecosystems that support the state's diversity of life* (NHESP 2001). The Lower Worcester Plateau ecoregion contains significant acreages of both "core" habitats and "supporting natural landscapes" identified by the BioMap project (Figure 8). More than 50 % of the ecoregion is classified as core or supporting natural landscape, compared to 42% statewide.

The BioMap Core areas are largely a reflection of known occurrences of rare plants and animals, plus examples of uncommon natural communities in the state. The LWP ecoregion contains a number of these habitats. For example, the NHESP program lists 148 known occurrences of rare wetland wildlife species in the ecoregion (Figure 9).

Recently, the NHESP released the "aquatic version" of BioMap (referred to as "Living Waters") to promote the strategic protection of freshwater biodiversity in the state (see www.state.ma.us/dfwele/dfw/nhesp/nhaqua.htm). That effort identified more than 27,000 acres in the

LWP ecoregion as "Core Habitats" (i.e., the lakes, ponds, rivers and streams that are important for the protection of freshwater biodiversity), along with an additional 241,395 acres of "Critical Supporting Watersheds" (CSW, i.e., areas with the highest potential to sustain or degrade Core Habitats) (Figure 10). The latter (which includes the core habitat areas) amounts to approximately 35.4% of the LWP ecoregion. In comparison, about 26.6% of the state as a whole is considered to be CSW.

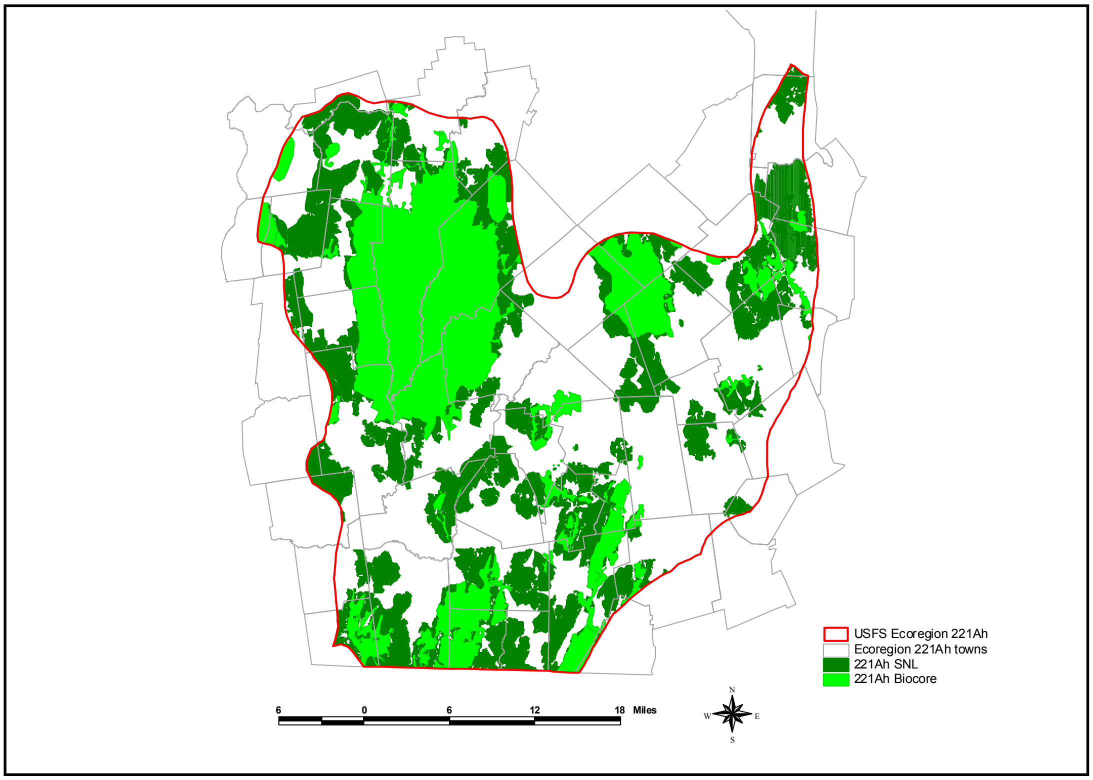

Figure 8. BioMap core and supporting natural landscape areas in the Lower Worcester Plateau ecoregion.

Wildlife Resources in the Lower Worcester Plateau Ecoregion

Dramatic changes in animal species composition have occurred over the past few centuries both in this ecoregion and across the entire Massachusetts landscape. These changes continue today with the resurgence of various bird and mammal species including black bear, wild turkey, moose, bald eagle, and beaver to name just a few. Other changes have not been as welcome, including the extirpation of species such as the passenger pigeon and the Atlantic salmon. Still other species have expanded their natural ranges into Massachusetts, including the American coyote and the cardinal, and some (like the coyote) have assumed important roles in wildlife community dynamics (http://www.state.ma.us/dfwele/dfw/dfwcoy.htm). In addition to changes in native animal species, recently introduced (or exotic) species have the potential to degrade ecosystems (examples include the mute swan and the zebra mussel). Forest resources in the LWP ecoregion provide the bulk of wildlife habitat, and the sustainable management of the region's forests is paramount to maintaining viable populations of native animal species.

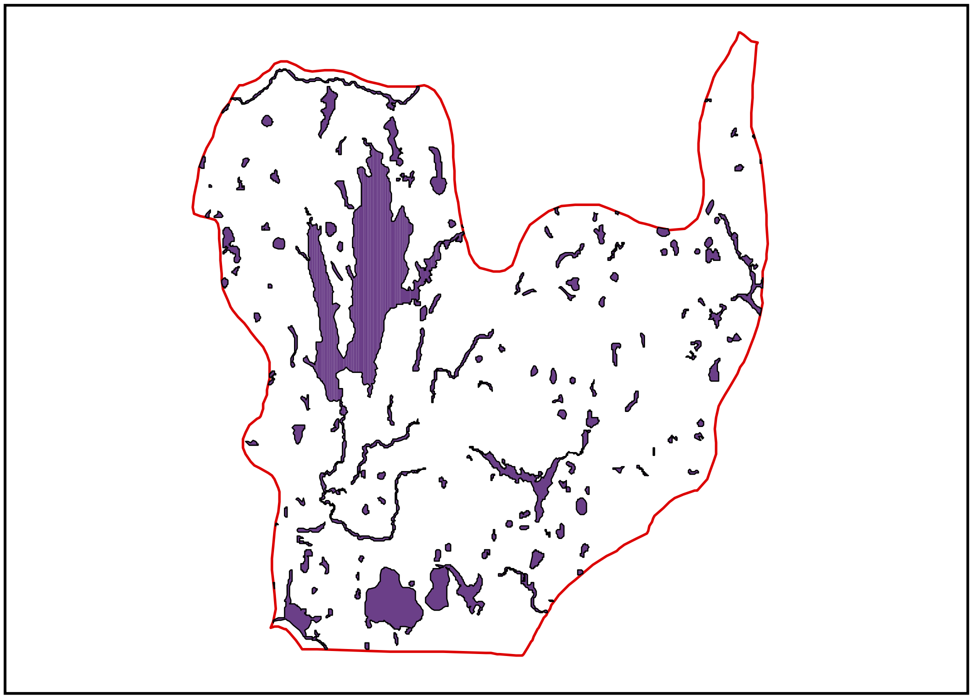

Figure 9. Estimated habitat occurrences of rare wetland wildlife species in the Lower Worcester Plateau ecoregion.

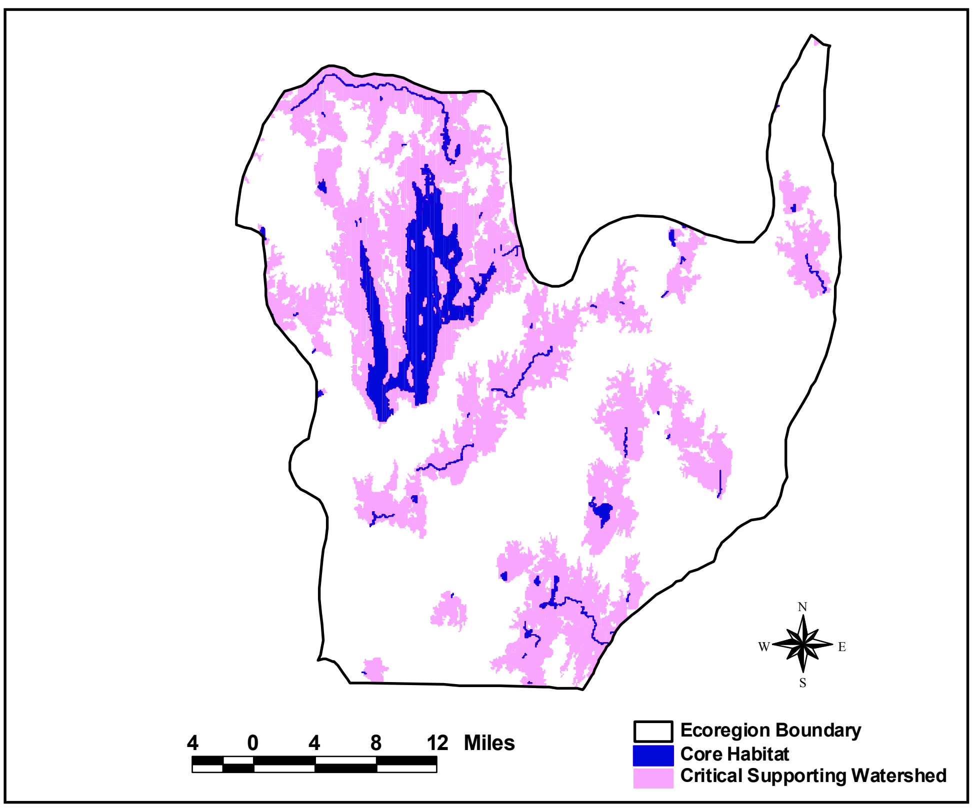

Figure 10. Core Habitat and Critical Supporting Watershed areas in the LWP Ecoregion.

These dramatic changes in animal species composition are largely the result of human landuse history from the 1700's to today (see Historical Trends in Forest Composition in Section IV) and unsustainable human consumption of fish & wildlife resources during the eighteenth and nineteenth centuries. An excellent recent summary on this topic is provided in Foster et al. (2002).

Today, fish and wildlife harvest is regulated by the Division of Fisheries and Wildlife, and conservation efforts are in place for rare species through the Division's Natural Heritage program (www.MassWildlife.org). However, human landuse continues to impact animal species in the ecoregion as open grassland and shrub habitats continue a century-long decline, as remaining wetlands, riparian habitats, and extensive forest habitats are degraded or fragmented by road infrastructure and other development.

Reclamation of open land habitats is appropriate at the periphery of extensive forestland, and ecological restoration of degraded habitats is essential to conservation of several state-listed rare species (endangered, threatened, and special concern). The Division of Fisheries and Wildlife's Biodiversity Initiative (www.MassWildlife/dfwele/dfw/bdi/Bdihome.htm) and numerous other public and private conservation efforts are attempting to address these issues (see Appendix III). Sustainable forest management within the LWP ecoregion can substantially reduce future habitat reclamation and restoration needs.

Forest conservation issues in this ecoregion affect fish and wildlife resources at two levels. First and foremost, extensive, unfragmented forests must be maintained in the face of burgeoning development (see section on the sprawl front) to sustain viable populations of native animal species (see recent Natural Heritage efforts focusing on terrestrial and aquatic freshwater habitats at http://www.state.ma.us/dfwele/dfw/nhesp/nhbiomap.htm, and http://www.state.ma.us/dfwele/dfw/nhesp/nhaqua.htm). Secondly, establishment and maintenance of the full range of forest communities and successional stages is needed to conserve the full complement of animal biodiversity. Biodiversity conservation issues and efforts are summarized in three Natural Heritage publications: 'Our Irreplaceable Heritage' (Barbour et al. 1998), 'BioMap' (NHESP 2001), and 'Living Waters' (NHESP 2003).

Fragmentation of extensive forestlands limits dispersal of various plant and animal species, and can foster the establishment and spread of invasive exotic species. On average, larger tracts of forest support more species than smaller tracts of similar forest types. The issue of forest fragmentation is further discussed in a following section of this assessment.

While forest cover represents the dominant landuse in Massachusetts today (www.state.ma.us/mgis/landuse_stats.htm), forests in this ecoregion and across the state are generally even-aged (70-90 years) as they recover from both natural and human disturbances including agricultural land abandonment and the 1938 hurricane. The paucity of both early-seral (<10 years-old) and late-seral (>150 years-old) forest habitat restricts wildlife community diversity, and sustainable management featuring both the harvest of renewable wood products, and the establishment of forest reserves can potentially enrich wildlife diversity in the Commonwealth (see, for example, existing forest management guidelines for state wildlife management areas at www.state.ma.us/dfwele/dfw/dfwpdf/dfw_forest_mgt_guide.pdf).

Potential impacts on state-listed rare species by forest cutting operations

The Department of Conservation & Recreation and the Division of Fisheries & Wildlife consult with the Massachusetts Natural Heritage and Endangered Species Program relative to state-listed rare species and priority natural communities that are known to occur on state lands in the Lower Worcester Plateau ecoregion. Property managers use this information to mitigate potential negative impacts to these species and communities during the management planning process.

Within the Lower Worcester Plateau ecoregion, forest cutting near wetlands, vernal pools, and within riparian filters has the greatest potential to impact listed species. Dragonflies (Odonates) such as the Spatterdock Darner (*Aeshna mutata*)(E)[3] occur in wetlands and benefit from maintenance of intact forested buffers around the edges of open wetlands. Amphibians such as the marbled salamander (*Ambystoma opacum*)(T), and crustaceans such as the intricate fairy shrimp (*Eubranchipus intricatus*)(SC) occupy vernal pools, and benefit from retention of mature forest canopy surrounding the pools, and buffering of harvesting machinery away from pools. Dragonflies such as the clubtail (*Stylurus spiniceps*)(T) and the brook snaketail (*Ophiogomphus asperus*)(SC) occur along stream corridors, and benefit from retention of riparian forest. Vascular plants such as Long's bulrush (*Scirpus longii*) occur in a fresh water marsh in this ecoregion and benefit from retention of forest along the edges of the marsh. Other plants such as ginseng (*Panax quinquefolius*)(SC) and Drooping Speargrass (*Poa languida*)(E) are associated with shaded conditions beneath a forest overstory. Forest cutting practices can occur without negative impacts on listed species, provided that their occurrence is know to managers and appropriate mitigation is built into the planning process.

A list of all natural communities and listed species known to occur within the Lower Worcester Plateau ecoregion is found in Appendix II. Additional information on natural communities and listed species for individual towns within the ecoregion can be obtained from the Massachusetts Natural Heritage & Endangered Species Program on-line at: http://www.state.ma.us/dfwele/dfw/nhesp/nhtown.htm. Information on the federal status of species can be found on-line at: http://www.natureserve.org/explorer/statusus.htm.

Vernal pools represent another important habitat for biodiversity protection. The Natural Heritage and Endangered Species Program (NHESP) has identified 3398 "potential vernal pools" in the ecoregion (Figure 12). More than 280 pools have been "certified" to date.

Wildlife habitat value is largely influenced by the types, condition and successional stages of land cover types. The maintenance of regional biodiversity will ultimately depend on maintaining a mix of habitat types and conditions, including successional stages. While natural disturbances may result in some degree of habitat and seral stage diversity, it is generally acknowledged that active forest management plays an important role in providing such habitat diversity in a more planned and predictable manner. The DFW has adopted forest composition goals for their Wildlife Management Areas that were based on the work of the USFS (DeGraaf et al. 1992). Those guidelines, which are intended to promote high overall wildlife diversity within New England forested landscapes, call for the following mix of forest size classes: 5-15% seedling (early-seral forest), 30-40% sapling–pole, 40-50% sawtimber and <10% large sawtimber. In the absence of site-specific management goals, we consider this to be a good general goal for habitat diversity.

As shown previously (see Table 2), the Lower Worcester Plateau ecoregion is dominated by forest cover (73%). Less than 9% is agricultural or open, and approximately 6% is wetlands or open water. USFS data shows that the majority of the forestland in this ecoregion is "mature" (i.e., in sawtimber classes). About 26% is in "poletimber" stage, and only 2.3% is in early seral stages (i.e., seedlings or saplings). This age class distribution is even more skewed towards older stands than statewide figures (Figure 13). As a result, the wildlife community in this ecoregion at the present time is likely to be dominated by species adapted to mature forest conditions.

Habitat value is also influenced by decisions made during both the marking and actual harvesting of forest stands. In addition to protecting uncommon or known rare species habitats, land managers should also plan for the maintenance of specific habitat conditions such as coarse woody debris, snags and den trees, and other landscape features important to wildlife species.

[3] (E) = Endangered; (T) = Threatened; (SC) = Special Concern

Fisheries Resources in the Lower Worcester Plateau Ecoregion

The Lower Worcester Plateau ecoregion is home to a wide diversity of fisheries resources. Portions of seven major drainage basins occur within the ecoregion (Figure 5), however, portions of the Chicopee and Quinebaug basins comprise most of the ecoregion. DFW has conducted intensive fish sampling efforts in both the Chicopee and Quinebaug basins, as well in the Nashua, Millers, Blackstone, and Connecticut watersheds as part of its statewide monitoring and assessment program (see program description below).

Extensive research has been conducted in the Quinebaug watershed to outline specific watershed-based restoration efforts using fisheries information. This research has been conducted cooperative multi-state and federal partnership with Millenium Power Partners and Cornell University. The objective of the research is to determine the best way to restore and protect the fisheries community of the Quinebaug watershed. This research has had, as one of its primary products, the development of a Target Fish Community (TFC). The TFC methodology is being applied in other watersheds in Massachusetts as well. Further research in all watersheds will include the establishment of TFCs, habitat mapping and the development of Indexes of Biotic Integrity (IBIs) to assess the aquatic resources across the state.

Since 1999, DFW has conducted 113 samples on 57 waterbodies within the LWP ecoregion (Figure 11). More than 105 coldwater fisheries resources have been identified within the LWP. More than 18,000 fish were collected of 32 species of fish. Data collected in the LWP will be used to identify high priority sites for restoration, excellent fishery resources, and priorities for land acquisition. Summaries of the fish communities within the LWP will be prepared that will describe the fishery resource on a watershed and sub-watershed scale.

The DFW Statewide Fisheries Monitoring and Assessment Program

Program objectives are to focus available DFW resources on a watershed basis to:

1. Assess the current status of fisheries resources.
2. Create a comprehensive fisheries database.
3. Develop watershed-based fisheries management plans.
4. Conduct environmental review and assessment.
5. Identify watershed lands that need to be protected as open space for protection and restoration of fisheries habitat and public access.
6. Identify factors and activities causing adverse impacts to fisheries habitats and uses.
7. Provide technical assistance and biological data to government agencies and private organizations involved in watershed management and protection.
8. Identify potential fisheries and habitat restoration projects for volunteers and watershed participant action plans.

The fishery assessment gathers information about fish species diversity, relative abundance and length frequency distribution. Backpack, barge, and boat-operated electrofishing units are the primary sampling mechanisms. Backpack shockers are best used in small shallow streams and are designed for headwater reaches. Barge electroshockers are designed to be used in wadeable streams with depth or current flow that make backpack shockers inefficient. Boat shockers will be used in lakes and rivers that are too deep to wade and where more power output is required.

Sampling locations are selected based on available access, water conditions and habitat type. Fish sampling crews conduct site visits to rivers and lakes to determine suitable access locations and sampling sites. Lotic habitat types (riffle, run, pool, etc.) and lentic habitat types (eutrophic, mesotrophic, oligotrophic) will be sub-sampled in proportion to their availability as determined by site visits. Data collection will take place from May 15 to September 15.

Stream and River Sampling

Crews of three to five people conduct single pass electrofishing surveys through previously selected sites. The beginning and ending points will be marked on USGS 1:25,000 topographical maps. Sample sites include at least 100 meters of stream length. In situations where100 meter reaches are not practical or possible, length of stream sampled is measured by tape.

Crews begin at the downstream end of a sampling site and shock to the upstream ending point. Crewmembers use dip nets to capture fish that roll off the bottom or rise to the surface. All fish are kept alive in five-gallon buckets, livecages positioned along the sample reach, or a livewell in the boat.

Lake and Pond Sampling

Crews of three to five people sample shoreline areas by making a single pass with an electrofishing boat. The beginning and ending points for the sampling site are marked on USGS 1:25,000 topographical maps. The crew conducts at least three total-pickup collections of at least 15 minutes each. During this process, all fish are collected and placed into the boat livewell. Other sampling methods (gillnet, seine) might also be employed to most effectively meet the sampling objective.

Data Collection

The first 100 fish of each species will be identified and measured to the nearest millimeter (except American eels and sea lampreys that will be measured to the nearest centimeter). The remaining fish in each species are tallied by species with no length taken. No more than two percent and no less than two individuals (or one if only a single specimen is collected) of each species captured will be preserved in 10% formalin for confirmation of identification by laboratory analysis. Live fish that are not retained for preservation are returned to the sample site.

Habitat Evaluation

Qualitative habitat assessments are conducted in conjunction with fish sampling to evaluate the condition of the available habitat as it relates to fisheries resources. Stream width, canopy enclosure and species composition, channel morphology, and anthropogenic influences are noted and assessed. Standardized habitat evaluation forms are also used to assess habitat quality. Lake habitat is characterized by morphology, local development and land use practices. Format and content of the information to be gathered concerning habitat measurements follows established guidelines used by the Department of Environmental Protection (DEP) and the Fisheries Section.

Analysis

Information gathered during the course of the study will be entered into a database designed to be accessible to all parties involved with watershed management. Microsoft Access will be used as a standard format for data entry, storage, and manipulation. Initial summaries will be generated by statistical software to outline and highlight the information gathered during the sampling period. Summaries will include information about sampling locations (number of sites, towns sampled), sampling effort statistics (length of river sampled, types of gear used, estimates of efficiency), number and description of species encountered (relative abundance, common and scientific names, literature-documented tolerances) and habitat scores or descriptions for the sample sites. Further analyses relating habitat and fishery characteristics will be provided in final reports and will focus on delineating change in fishery characteristics with changes in available habitat.

Products

Several key products will result from this effort. This information will be used internally for several purposes. Habitat and fisheries assessments will be compiled in a database that will be used by the Fisheries Section for resource management, environmental review and assessment, land acquisition programs, and public access prioritization. Completed watershed-based fisheries management plans will include summarized information from fisheries and habitat assessments and suggest options for improving habitat quality. Examples of these projects include in-stream fish structures, riparian stabilization, maintenance of buffer strips, and public involvement and outreach.

One of the key products emerging from the Assessment process is the development of Target Fish Communities. The Target Fish Community methodology was developed to describe a community of fish, using regional distribution and local relative abundance data that is appropriate for a natural river in southern New England. The TFC is used as a benchmark for assessing comparability to an existing community and to identify the nature of departures from the TFC. To date the TFC process has been employed in the Quinebaug and Ipswich Rivers and the intent is to establish them statewide.

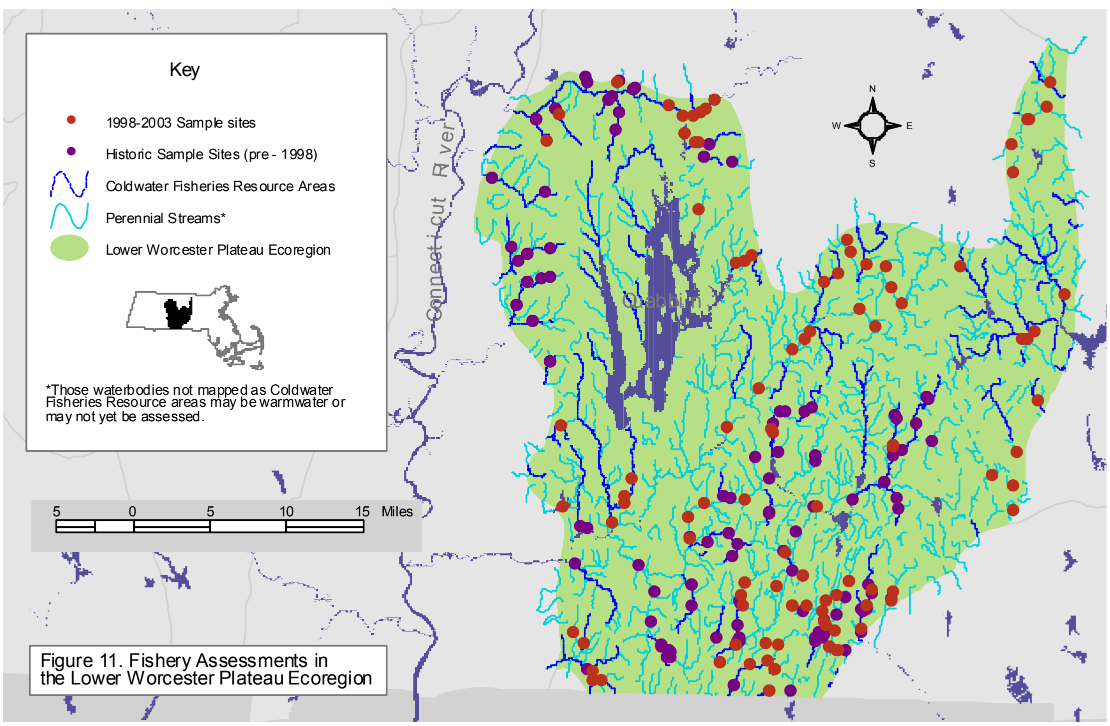

Figure 11. Fishery Assessments in the Lower Worcester Plateau Ecoregion

Figure 11. Locations of fisheries assessments in the LWP ecoregion.

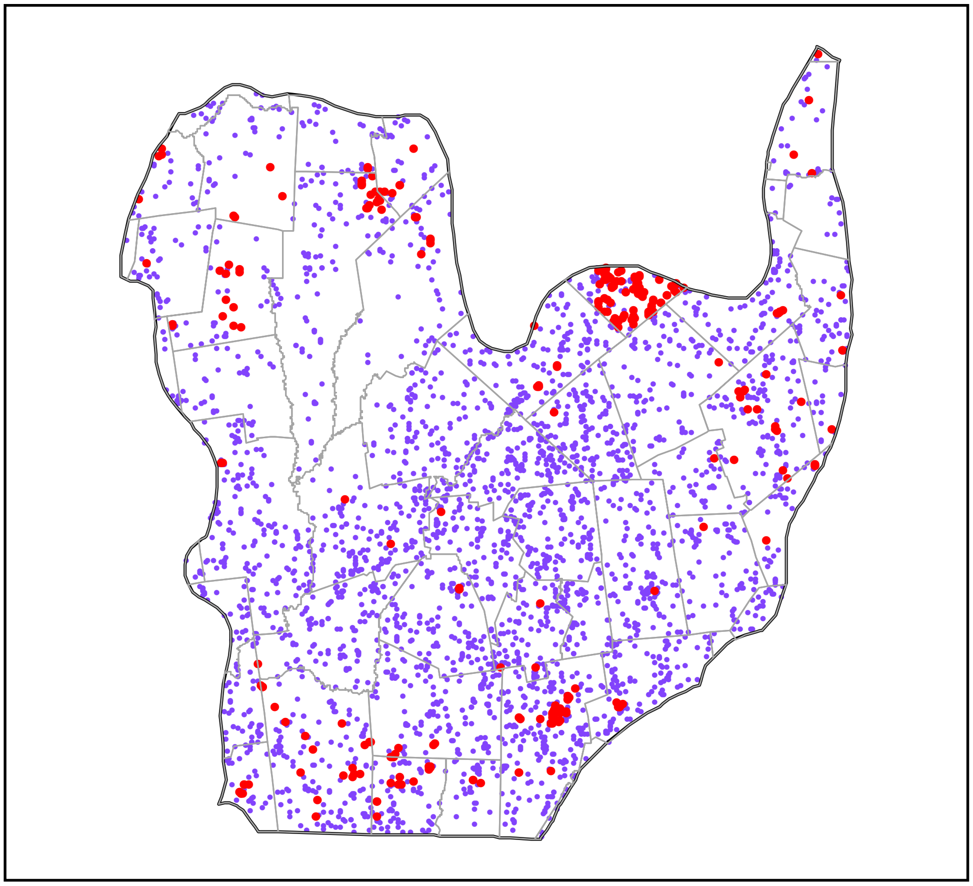

Figure 12. Potential and certified (larger dots) vernal pools in the Lower Worcester Plateau ecoregion.

A Forest Reserve System for Massachusetts and the LWP Ecoregion

The current scientific literature documents the benefits of having areas of forestland that are reserved from extraction of both non-renewable natural resources (e.g., fossil fuels and gravel) and certain renewable resources including wood products (see for example Alverson et al. 1994, Vora 1994, Hunter 1996, Andersen 1999 and Norton 1999). Forest reserves help ensure that representative examples of biodiversity indigenous to an area are conserved, and also provide reference sites for objective assessment of the sustainability of extractive forest management practices (Norton 1999). The Forest Stewardship Council requires certified forest operations to include conservation zones and protection areas that function to support rare, threatened and endangered species and their habitats, as well as protecting representative samples of existing ecosystems within the certified properties. The Nature Conservancy (TNC) has promoted the establishment of relatively unfragmented 'matrix' forest communities on an ecoregion basis as a viable means of biodiversity conservation in the Northeast (Andersen 1999).

Forest reserves are important for practicing adaptive resource management (Walters and Holling 1990). Reserves create opportunities for connectivity within the landscape, conservation of species and processes, buffering against future uncertainty, and other hard to measure but valuable functions (Hunter 1996). Potential benefits of forest reserves include development of primary herbaceous communities on the forest floor (Meier et al. 1995), unique assemblages of lichens and bryophytes (Dunwiddie et al. 1996, Flatebo et al. 1999), and possible development of unique micro-invertebrate communities with accumulated woody debris and intact forest soils.

Overall, forest reserves in temperate North America are warranted for biodiversity conservation, but it must be recognized that local production of renewable wood products is also essential to avoid shifting wood harvest to other regions of the world with less stringent environmental regulations (Berlik et al. 2002) which can potentially exacerbate tropical deforestation (Sohngen et al. 1999). In Massachusetts, the economic value to rural communities of forest management must also be considered.

It must also be recognized that the concept of forest reserves is not fixed, and that it will continue to develop and evolve as our knowledge and understanding of reserve function increases over time. Given that the future is uncertain, a reserve system needs to be adaptive, and to retain the ability to add, subtract, and exchange areas within a landscape context to benefit both biodiversity conservation and social concerns over time. Within Massachusetts, state lands should serve as models to private ownerships of both state-of-the-art sustainable forestry and careful selection of appropriate forest reserves.

For forestry practices to be certified as sustainable, FSC requires the conservation of biological diversity, critical resources, and unique and fragile ecosystems in order to maintain ecological functions and integrity. Specifically, FSC requires:

1. The establishment of conservation zones and protection areas that protect rare, threatened, or endangered species on the property.
2. The protection of representative samples of existing ecosystems. These samples must serve to establish or maintain reference conditions, protect under-represented conditions, and/or protect sensitive, rare, or unique features.

Each of the three EOEA divisions participating in the SCS/FSC forest "green" certification audit (DSPR, DWSP, and DFW) has previously made independent efforts to incorporate some aspects of a forest reserve system into their land management planning. Examples include the DSPR old-growth forest policy and GOALS zoning of 'protection' forest, the DWSP 'areas of special management restrictions' in the Quabbin and Wachusett land management plans and 'strategy 1' lands in the Ware River land management plan, and the DFW provision that 10-15% of state wildlife lands occur as late-seral forest habitat. Each of these various efforts generally restricts or prohibits extraction of wood products, and imposes other management restrictions. SCS has accepted the current system of unmanaged lands within DWSP properties as meeting FSC requirements. Approximately 19% (18,500 acres) of DWSP properties on its three main watersheds are designated as unmanaged or restricted. Approximately 15,000 acres of this total is in the LWP ecoregion (representing more than 11% of the approximately 134,000 acres of state lands in the ecoregion). These lands include islands within the reservoirs, steep slopes, wetlands, vernal pools and other rare and endangered species habitats, the 1,100 acre Pottapaug Natural Area, the 213 acre Poutwater Pond Nature Preserve, and a variety of other parcels throughout the watersheds. To meet FSC and SCS conditions, DFW and DSPR are required to designate a similar system within three years of certification. SCS states that ideally Massachusetts will dedicate more than 15% of their total state forest system to reserves.

A variety of inter-related ecological attributes have been proposed as important in reserve design, including representativeness (inclusion of a wide range of natural variation characteristic of a region), species-area relationships (larger areas tend to support more species than smaller areas of the same habitat type), metapopulation dynamics (migration between spatially discrete population assemblages), landscape position (minimizing fragmentation and providing connectivity), natural disturbance regimes (accounting for infrequent, large-scale disturbance), climate change (inclusion of elevation and aspect gradients), and restoration ecology (inclusion and rehabilitation of human-modified environments when few or no quality examples remain on the landscape [e.g., floodplain forest])(Norton 1999). Another vital component of reserves is management of the matrix lands surrounding a reserve that are open to wood products extraction. Application of extended rotation silviculture with retained 'islands' of mature trees in areas adjacent to the reserve has the potential to substantially enhance biodiversity conservation within the reserve (Norton 1999).

Both occasional large and multiple small forest reserves representing a wide range of ecological diversity are warranted to meet the purposes of forest reserves (Vora 1994). Designation of reserves at multiple scales (including small patch communities, large patch communities, and extensive, relatively unfragmented 'matrix' forest communities) is promoted by The Nature Conservancy (TNC) – an international organization that has broad and various forest protection, forest management, forest reserve design, and forest certification experience. TNC has promoted planning on an ecoregion basis as a viable means of biodiversity conservation in the Northeast (Andersen 1999).

Multiple small and large patch reserves can form key components that protect particular combinations of biodiversity that are not present elsewhere in the landscape, and can facilitate plant and animal migration that sustains viability of metapopulations (Andersen 1999, Norton 1999). Occasional large 'matrix' reserves of ≥15,000 ac in Northeastern forests can likely absorb infrequent large-scale disturbances and allow re-colonization of disturbed sites from adjacent, undisturbed portions of the reserve (Alverson et al. 1994, Andersen 1999). Accordingly, EOEA will undertake a state-wide process to identify potential small and large patch reserves on state lands, and also facilitate public-private partnerships to identify potential matrix reserve sites on combinations of public and private lands (see below).

EOEA will consider reserve criteria and methodologies recommended by TNC (Andersen 1999) in order to establish a science-based process for the assessment and establishment of forest reserves in Massachusetts. EOEA will provide TNC and other interested parties an opportunity for input into the final methodology and criteria selected. This process will help identify potential small and large patch reserves on state-owned forestlands. EOEA will also utilize the existing work of TNC to evaluate the potential for creating occasional large 'matrix' reserves (i.e., of 15,000 + acres) in Massachusetts through voluntary public-private partnerships involving appropriate EOEA lands, other public lands, private conservation lands, private non-industrial forestlands, and various conservation organizations. TNC has recently completed an ecoregional analysis of viable and representative forest areas in the Northeastern United States (Anderson and Bernstein 2003) that could facilitate discussion of occasional large 'matrix' reserves in Massachusetts. Given the current ownership patterns of land in Massachusetts (including state lands), the establishment of occasional, large 'matrix' reserves would undoubtedly require voluntary public-private partnerships involving both landowners and a variety of conservation organizations.

The EOEA-led reserve identification process will provide opportunity for public input, and will occur concurrently with the development of a series of ecoregional assessments. These assessments will identify a range of natural resource issues, concerns and opportunities including providing guidance on forest reserves. Drafts of forest reserve documents and ecoregion assessment documents s will be posted on the EOEA web site, and public comments will be welcomed. Summaries of public comments, and EOEA response to comments will be included as an appendix in subsequent drafts of these documents. In addition, occasional public presentations will be given by EOEA in different portions of the state to address ecoregion assessments and potential forest reserve sites. These efforts will also meet FSC certification requirements, and will coordinate previously independent agency efforts across 500,000 acres of state lands.

The state is also conducting forest planning on state owned lands to meet certification of sustainable forest management standards. The forest plans that are being developed will include use of the reserve criteria and methodology principles to identify and delineate reserves. When necessary, forest plans may need to be updated to reflect final information as a result of the forest reserve assessment.

Landuse Trends and Forest Fragmentation

Trends in landuse in the ecoregion from 1985 through 1999 show a decline in acreages of agricultural/open land and in forest cover, with a corresponding increase in the amount of developed land (Table 2). While 65% of this change came at the expense of the forest cover, the loss of more than 6,300 acres of agricultural and openland during this period is also of concern, since it represents almost 10% of the total acreage of that cover type. These trends also impact species composition and biodiversity in the ecoregion. Further, recent data from EOEA and the Massachusetts Audubon Society shows that the “sprawl front” in the state is just to the east of this ecoregion (Figure 14). Thus, the trend of increasing developed land with a corresponding loss of forest and openland could be greatly accelerated in future years in this ecoregion.

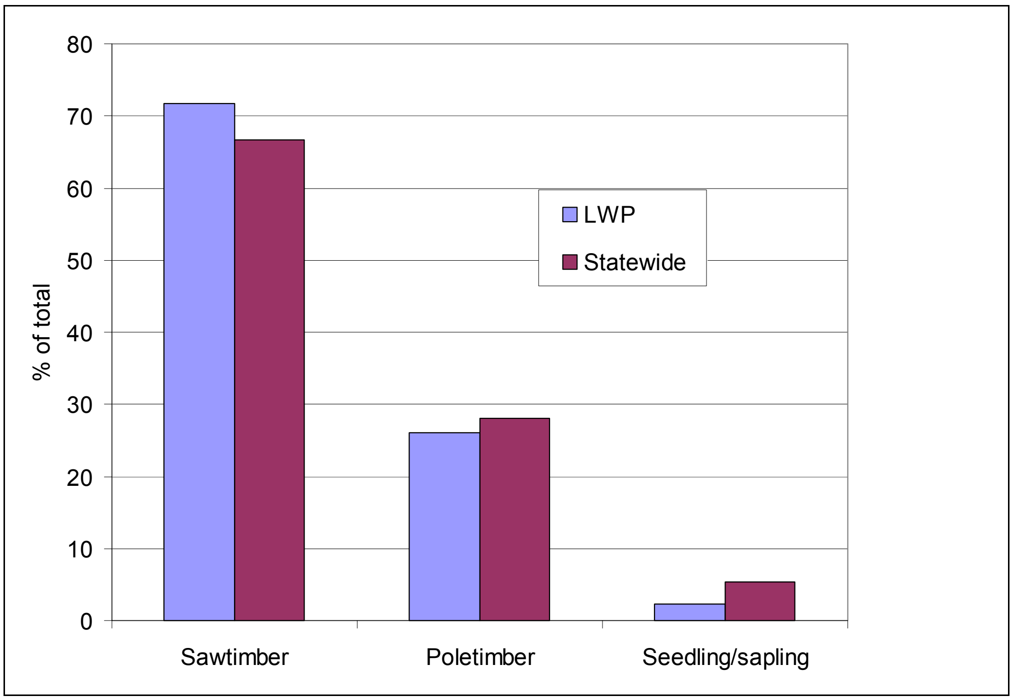

Figure 13. Age class distribution of forestland in the Lower Worcester Plateau ecoregion and statewide, 1999.

Associated with the loss of forest cover is the sub-dividing or fragmentation of existing forested areas. This trend is not unique to this ecoregion. US Forest Service data shows that statewide, the average size of forested parcels continues to decline. It is estimated that the number of landowners with fewer than 50 acres of timberland has more than doubled since 1973 (USFS 2002). Further, the most recent Forest Service survey of timberland in Massachusetts showed that nearly 75% of forested sample points were within ¼ mile of the forested edge, thus potentially subjecting them to more human influences and other edge effects than areas that are more distant from developed land (USFS 2002).

Although forest fragmentation is undoubtedly occurring in the Lower Worcester Plateau ecoregion, it appears that it is not a major issue at the present time. MassGIS data on contiguous natural lands (Figure 15) suggest that this ecoregion has significant areas in relatively contiguous forest cover.

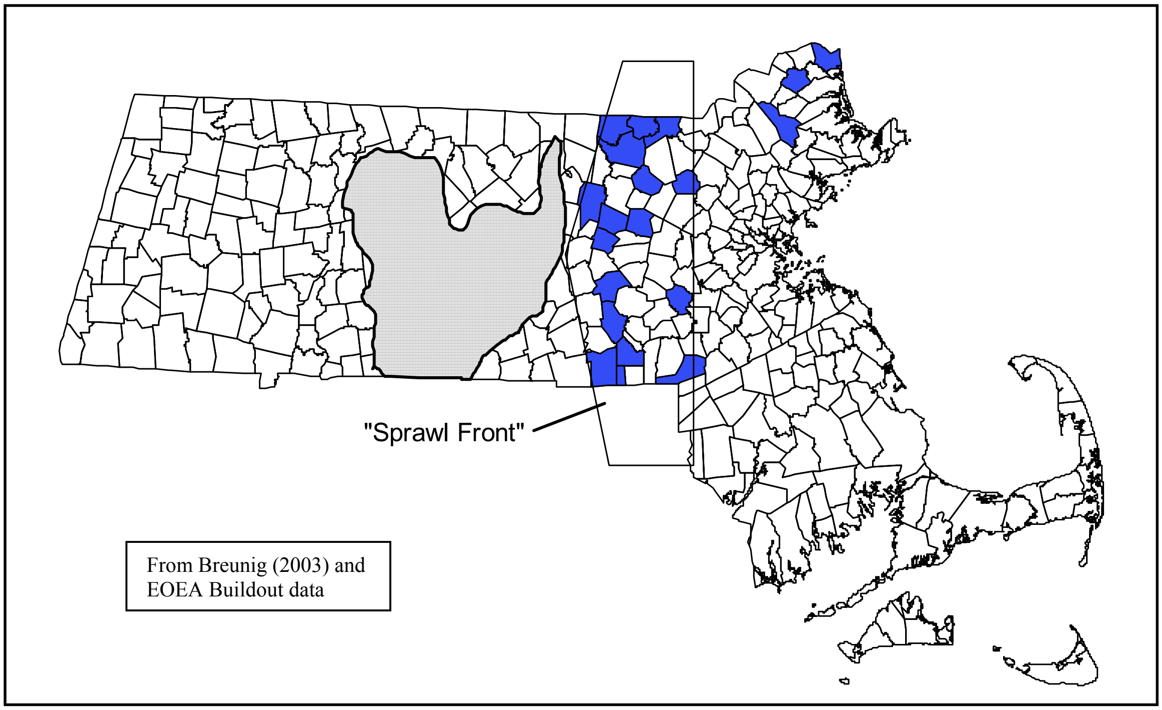

Figure 14. Top 20 towns in terms of acres per housing unit, and the “Sprawl” front in Massachusetts.

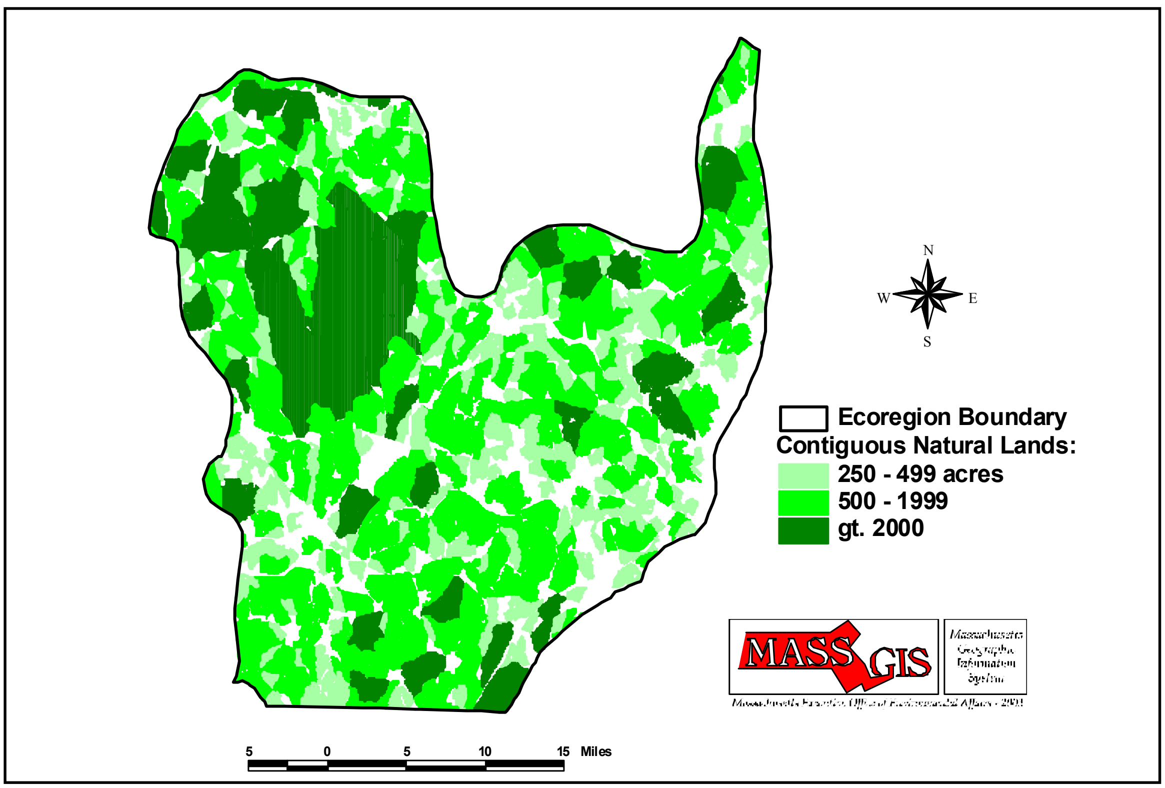

Figure 15. Contiguous natural lands in the Lower Worcester Plateau ecoregion.

Invasive Plants

Another potential threat to the future forest and habitat conditions in the ecoregion is the proliferation of invasive plant species. The potential impacts of invasive plants are just beginning to be fully understood. The following is taken from a draft Strategic Plan for Managing Invasive Plants in Massachusetts, currently being prepared by the Massachusetts Invasive Plants Working Group:

> *The problem of invasive plants has been widely articulated. Invasive species are second only to habitat destruction in threatening extinction of native species, and according to the Department of the Interior cost our national economy an estimated $123 billion annually. To give but one example from Massachusetts, in the Connecticut River valley Phragmites australis or Common Reed is moving toward domination of the species composition in wetlands previously demonstrated to be of international importance as exemplary communities (The Connecticut River Watershed/Long Island Sound Invasive Plant Control Initiative: Strategic Plan, March 1999).*
>
> *The invasive plants of greatest concern nationwide and to the Commonwealth of Massachusetts have reproductive advantages over native species. Having been transported out of their native environment, they are consequently free of the evolved biological controls that manage population expansions and maintain biological diversity in our region. Without these constraints, invasives have monopolized natural communities, out-competing a wide range of pre-existing natives. This monopolization can have substantial economic consequences, can impact rare and endangered species, can dramatically alter long-established balances of both species composition and habitat qualities, and may result in losses of both human uses and the ecological integrity of the affected environment.*
>
> *The changes accompanying invasions are often subtle, sometimes even visually attractive, so that the "problem" they pose is not always immediately obvious. Nevertheless the most opportune time to reduce the threats posed by invasive plants is before they become widely established, and optimally before new invasions occur. Many of these invaders have become so well established across our landscape that eradication of any given species is highly impractical unless the invasion is new and detected early.*
>
> *But this does not mean that nothing is possible. On the contrary, we have clear choices about how our landscape will look and how the ecosystems of the Commonwealth will function in the future. Among many other efforts to address this daunting problem, the Massachusetts Invasive Plants Working Group is developing a guidance document for setting priorities. The Massachusetts Invasive Plants Strategic Plan will maximize the efforts of a well-publicized collaboration between key public and private stakeholders, united in the recognition that invasive species pose a real threat to the ecology and economy of the Commonwealth, and committed to taking coordinated actions within their spheres of influence to deal with this problem effectively.*

Another important effort currently underway is the Invasive Plant Atlas of New England, (http://invasives.eeb.uconn.edu/ipane/index.html) a volunteer training and coordination effort to develop spatial and descriptive information documenting the current state of invasive plants in the region, as well as broad education of the public on the dynamics of invasions and methods for addressing the issues. IPANE is a relatively new effort, so that its database information is incomplete. Nonetheless, this database already holds 325 documented occurrences for 47 different species within the towns of the Lower Worcester Plateau ecoregion. 43 of the 51 towns in this ecoregion have documented occurrences of invasive plants, and it is extremely likely that those so far missing from the database are not invasive-free. To date, the most commonly documented species in the ecoregion are *Euphorbia esula* (leafy spurge) and *Rhamnus cathartica* (common buckthorn), although this does not mean these are the most extensive populations. *Lythrum salicaria* (purple loosestrife), amongst the most widely publicized wetland invasives, has also been commonly documented in Hampshire and Worcester counties by the IPANE project. Table 5 shows the currently documented occurrences of invasive plant species in the Lower Worcester Plateau ecoregion counties from the IPANE project. Additional information is provided in Appendix IV.

A number of "special places" occur in the Lower Worcester Plateau ecoregion including the Quabbin Reservation, the "lakes region" in the southeastern portion of the ecoregion, the major river systems, Norcross Foundation protected lands in the southern portion of the ecoregion, Harvard Forest lands in the northern portion, and a number of quaint historic village centers. The Poutwater Pond Nature Preserve, in the eastern portion of the ecoregion, was the first Nature Preserve to be established in the state. Finally, there are a number of State Forests and Wildlife Management Areas in the ecoregion, which provide a variety of habitats and outdoor recreation opportunities. Presently, there are no Areas of Critical Environmental Concern (ACECs) in the ecoregion.

Data on rare habitat and species locations in the ecoregion is continually being expanded and updated. For example, a survey of rare, unique and exemplary natural communities of the Quabbin Watershed was recently completed by researchers at the University of Massachusetts (UMass DNRC 2000). Such surveys provide valuable information on locations and uses of rare habitats (see Figure 16 for an example) that will be incorporated into future land protection and management planning.

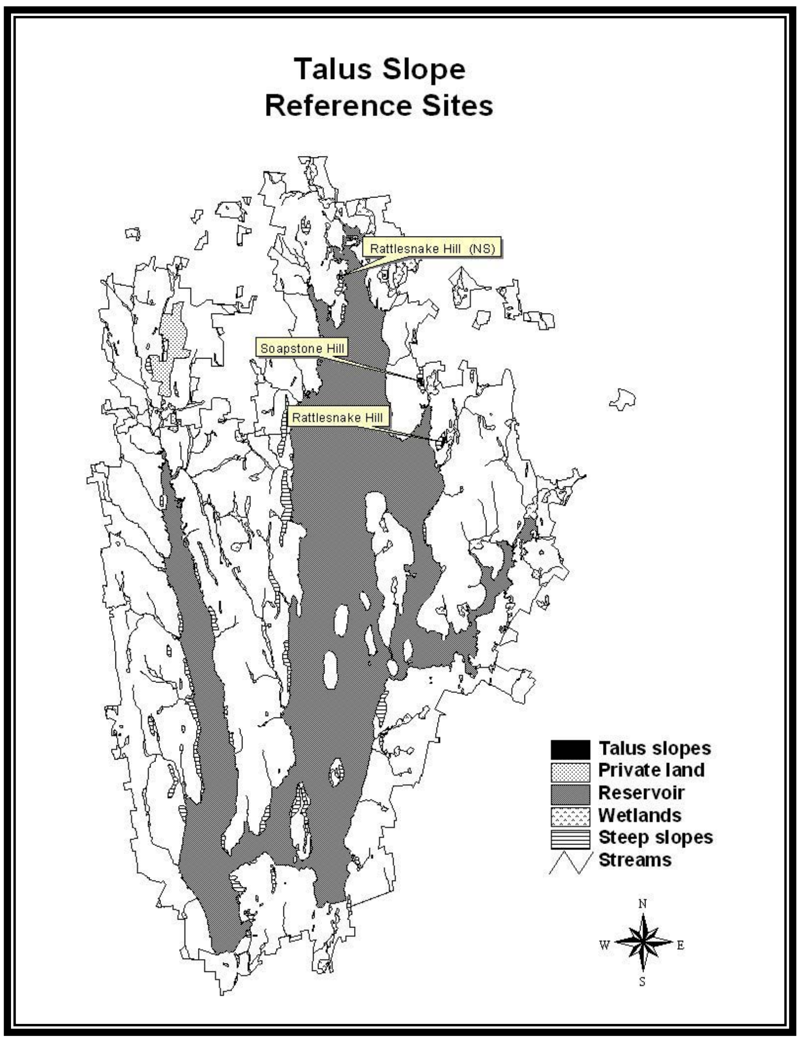

Figure 16. Example of rare habitat survey results from the Quabbin Reservation portion of the Lower Worcester Plateau ecoregion.

Table 4. Currently documented occurrences of invasive plant species in the Lower Worcester Plateau ecoregion counties[1].

		County				
Scientific name	**Common name**	Franklin	Hampden	Hampshire	Worcester	Total
Acer pseudo-platanus	Sycamore maple				1	1
Aegopodium podagraria	Goutweed			2	2	4
Ailanthus altissima	Tree-of-heavan				6	6
Alliaria petiolata	Garlic mustard				2	2
Amorpha fruticosa	False indigo			2		2
Ampelopsis brevipedunculata	Porcelain berry			1		1
Berberis thunbergii	Japanese barberry		2	2	2	6
Berberis vulgaris	European barberry		1			1
Cabomba caroliniana	Fanwort	4		1	6	11
Celastrus orbiculatus	Oriental bittersweet		2	1	2	5
Centaurea biebersteinii	Spotted knapweed	1			6	7
Cynanchum louiseae	Louis' swallowwort	1		4	1	6
Elaeagnus angustifolia	Russian olive				2	2
Elaeagnus umbellata	Autumn olive		6	2	2	10
Elsholtzia ciliata	NA			1	1	2
Epilobium hirsutum	Hairy willowherb	1			5	6
Euonymus alatus	Winged euonymous, Burning bush		1			1
Euphorbia cyparissias	Cypress spurge	2	2	7	11	22
Euphorbia esula	Leafy spurge				1	1
Fallopia japonica	Japanese knotweed	1		3	5	9
Frangula alnus	Glossy buckthorn	1	2	9	5	17
Froelichia gracilis	Slender cottonweed				1	1
Hesperis matronalis	Dame's rocket	1		6	3	10
Iris pseudacorus	Yellow iris			1	5	6
Lepidium latifolium	Broad-leaved peppergrass				4	4
Lonicera bella	Morrow/tartarian honeysuckle cross		2	1	1	4
Lonicera japonica	Japanese honeysuckle		1			1
Lonicera maackii	Amur honeysuckle				1	1
Lonicera morrowii	Morrow's honeysuckle	1	5	1	7	14
Lonicera tatarica	Tartarian honeysuckle			2	1	3
Lysimachia nummularia	Moneywort	5		3	5	13
Lythrum salicaria	Purple loosestrife			8	7	15
Myosotis scorpiodes	True forget-me-not	1	1	7	8	17
Myriophyllum heterophyllum	Variable water milfoil		3		9	12
Myriophyllum spicatum	Eurasian water milfoil				1	1
Nasturtium officinale	Watercress		1	3		4
Nymphoides peltata	Yellow floating heart				1	1
Phragmites australis	Common reed		1	2	3	6
Potamogeton crispus	Curly pondweed			1	1	2
Ranunculus repens	Creeping buttercup			9	7	16
Rhamnus cathartica	Common buckthorn	4	3	1	14	22
Robinia pseudoacacia	Black locust	3	2	4	4	13
Rosa multiflora	Multi-flora rose		7	3	5	15
Rubus phoenicolasius	Wineberry		1			1

Trapa natans	Water chestnut				1	1
Tussilago farfara	Coltsfoot	10	1	3	4	18
Vincetoxicum nigrum	Black swallow wort	1				1
Grand Total		37	44	90	153	324

[1]Data from the IPANE website (http://invasives.eeb.uconn.edu/ipane/index.html)

IV. Forest Conditions, Health and Productivity

This document provides management guidance for the development of future land management plans on state-owned lands. However, since most of those properties are mostly forested, those plans will be largely focused on forest management activities. Accordingly, data on past and current forest conditions will be presented so that those future management plans can be developed in an appropriate context. First, a summary of the historical trends in, and impacts to, local forestlands will be presented.

Historical Trends in Forest Composition

Assessment of current forest conditions, and determination of desired future condition are best accomplished with a thorough knowledge of past forest dynamics. An understanding of the background rates and causes of change in forested landscapes can help to guide conservation efforts on many scales (DeGraaf and Miller, 1996). Fortunately, early studies of forest composition in Southern New England prior to the time of European settlement do exist (Bromley 1935, Cline and Spur 1942, and Braun 1950), and these early studies have been augmented by recent, detailed historical research on forest dynamics (e.g., Foster et al. 1998, Fuller et al. 1998, Cogbill et al. 2002, Parshall and Foster 2002, Hall et al. 2002, Foster et al. 2002, Bellemare et al. 2002, and Gerhardt and Foster 2002).

Forest ecosystem structure, composition, and function are strongly conditioned by history, and modern conservation strategies must be based on an understanding of processes and events often occurring in the distant past (Foster et al. 2002). Forest ecosystems are dynamic as a consequence of disturbance and environmental change, and many biological processes unfold over century-long periods. These dynamics establish legacies in soils or ecosystem structure and composition that may endure for decades or centuries (Foster et al. 2002).

At the time of European settlement, the distribution of tree taxa and forest assemblages across Massachusetts showed pronounced regional variation, and corresponded strongly to climate gradients. The dominance of northern hardwoods and hemlock in the cooler uplands and oak and hickory at lower elevations is consistent with the regional distribution of these taxa and suggests a strong climatic control over broad-scale vegetation patterns (Foster et al. 1998). Vegetation in the cooler uplands of Massachusetts was a continuous geographical sequence typified primarily by beech among the northern hardwoods, while forests at lower elevations were typified by various species of oak (Cogbill et al. 2002).

Spatial, vegetational, and environmental patterns across Massachusetts prior to European settlement demonstrate a distinct "tension zone" separating northern hardwood and central hardwood areas. The pre-European-settlement northern hardwood forest (dominated by beech) forms a continuum responding to a complex climatic gradient of altitude and latitude. The oak forests to the south are distinguished by non-zonal units, probably affected by fire (Cogbill et al. 2002). Notably, this distinct tension zone includes the northern portion of the Lower Worcester Plateau ecoregion that stretches west from the town of Ashby into the town of Erving in the northwest portion of the ecoregion (Figure 17).

Based on historical and paleoecological data, it is unclear how extensive natural or aboriginal disturbance was in the Uplands (Parshall and Foster 2002), whereas infrequent surface fires in the Lowlands my have helped to maintain the abundance of central hardwoods and to restrict the abundance of hemlock, beech, and sugar maple in these areas (Foster et al. 1998, Fuller et al. 1998, Parshall and Foster 2002). It appears that the pre-settlement forest across Massachusetts did not contain as much white pine, hemlock and chestnut as previously thought (although each of these species was at times locally abundant), and that the tension zone between northern hardwood andcentral hardwood (mixed oak) forest was more distinct than previously thought (Cogbill et al. 2002). It also appears that following European settlement, the regional occurrence of white pine increased (Parshall and Foster 2002).

It is widely accepted today that the post-European settlement view of forests as commodities to be exploited led to a dramatic and drastic alteration of the forest landscape throughout Massachusetts during the 18th and 19th centuries (Foster et al. 1998). Past human disturbance (e.g., agricultural conversion and/or cutting), as well as human constraint of natural disturbance (most notably fire) has greatly modified overstory tree species composition on many sites (Foster et al. 1998, Abrams 1999). These alterations have obscured the regional forest patterns that corresponded to climate, substrate, and fire regime (Foster et al. 1998, Fuller et al. 1998). Modern vegetation is compositionally distinct from Colonial vegetation, exhibits less regional variation in the distribution of tree taxa or forest assemblages defined by tree taxa, and shows little relationship to broad climatic gradients. Among the most notable changes are a massive increase in red maple and birch in the southern portion of the Central Uplands (Foster et al. 1998).

Around the height of agricultural clearing in 1830, nearly 75% of the Lower Worcester Plateau ecoregion had been converted from forest to field (Figure 16). Today, the situation is essentially reversed, with about 83% of the ecoregion in forest due to agricultural abandonment in the late 19th and early 20th century. Within the Worcester-Monadnock region, modern forest vegetation is dissimilar to pre-settlement forests in terms of composition, inferred structure, and relationship to regional environmental gradients despite the extensive process of natural reforestation and forest maturation that has occurred over the past 100-150 years. Whereas forest vegetation per se has proven to be highly resilient to the human impacts and natural changes that have occurred during historical times, individual taxa have responded in highly variable ways to produce landscape patterns that contrast strongly with those of the colonial period (Foster et al. 1998).

While it is important to consider pre-settlement forest condition, it is equally important to remember that forest condition was not static prior to European settlement of Massachusetts (Fuller et al. 1998). Paleoecological studies have documented that species composition has shifted over the millennia within the general northern hardwood and oak forest types that originally dominated what is now Massachusetts, and this included historical changes within a portion of the Lower Worcester Plateau ecoregion, where dominance shifted from oak to chestnut then back to oak over the past few thousand years (Foster et al. 2002). Accordingly, there is no “ideal” or “original” forest composition to manage for today. Change is the norm in temperate forest landscapes, and management today occurs within a varied historical context.

While tree species composition of Massachusetts forestlands can be expected to vary widely, forest managers can realize many, if not all, habitat benefits associated with structural attributes of unmanaged forest landscapes by incorporating natural structural patterns into managed forestlands (Spur and Cline 1942, Franklin and Forman 1987, Hansen et al. 1991, Rowe 1992, Aplet et al. 1993, DeGraaf and Healy 1993, Franklin 1993, Mladenoff and Pastor 1993, Mladenoff et al. 1993, Noss 1993, Alverson et al. 1994, Lorimer and Frelich 1994, deMayndier and Hunter 1995, Meier et al. 1995, Yahner 1995, Hunter 1996, Rogers 1996, Lindenmayer and Franklin 1997, Foster and Foster 1999, Seymour and Hunter 1999). Forest cutting practices that incorporate structural patterns

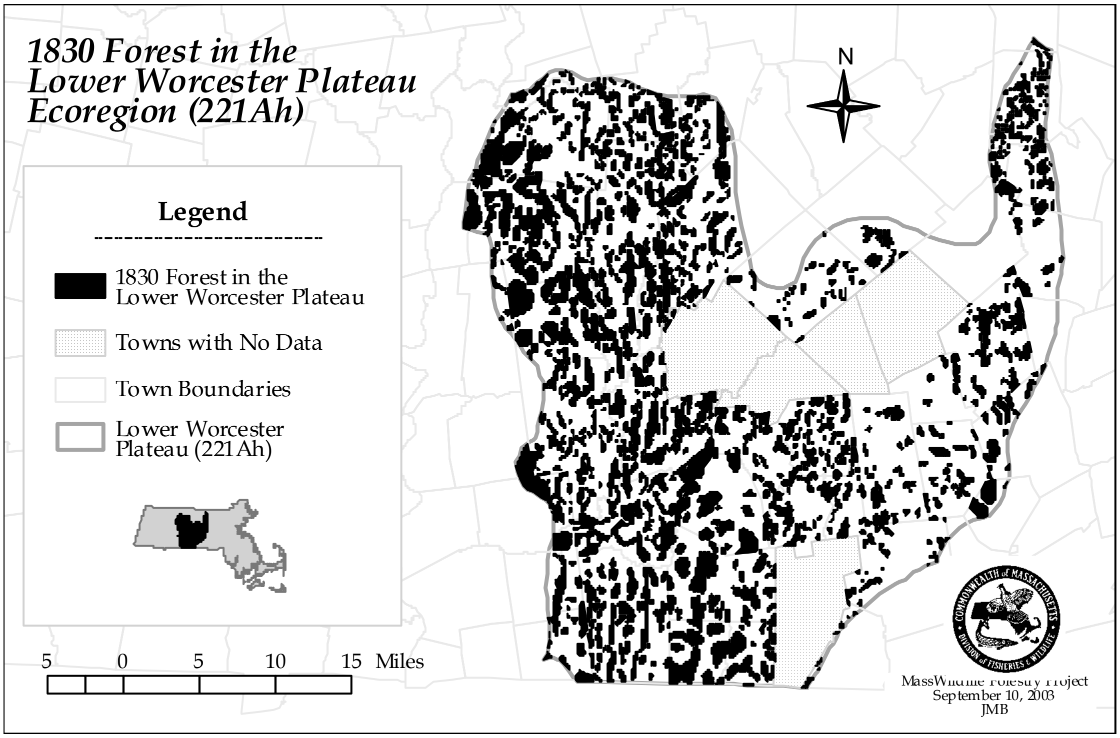

Figure 17. 1830 Forest within the Lower Worcester Plateau ecoregion.

associated with natural disturbance processes will help sustain the long-term productive potential of forests, maintain biodiversity, and provide a buffer against future uncertainties such as climate change (Mladenoff and Pastor 1993), natural disturbance (e.g., wind, fire, and insect infestations) (Foster and Foster 1999), and economic shifts in market conditions.

Current Forest Conditions

The USFS conducts periodic assessments of forest conditions under its Forest Inventory and Analysis (FIA) program. In this region, those assessments have most recently been conducted in 1984 and 1997-98. FIA data for the Lower Worcester Plateau are presented below. However, it should be noted that the FIA data is based on surveys of a limited number of plots, and when data is summarized for smaller units (e.g., an ecoregion versus the state as a whole), the accuracy of the estimate declines. Thus, while the data presented here paints a useful picture of the general forest conditions in the ecoregion, appropriate caution should be used in interpreting these estimates.

The FIA data supports the MassGIS-based estimates of a largely forested ecoregion, even more so than statewide (83% forested vs. 62% statewide). Almost 75% of the total forested acreage of this ecoregion is in the Oak/Pine (39%) and the Maple/Beech/Birch (35%) forest types (Table 5). Virtually all of the 10,081 acres of seedling/sapling forest in the ecoregion consists of pine (3,064 acres) and maple/beech/birch (7,017 acres) types.

When growing stock volumes are analyzed by diameter class, several trends are evident (Figure 18). First, red maple dominates the smaller diameter classes, accounting for almost 32% of the volume in the 5.0-6.9" diameter class of the most common species found in the ecoregion. Northern red oak comprises only 8.3% of the total volume in that diameter class. The small sawtimber classes are dominated by white pine and oaks. White pine also dominates the larger sawtimber classes, reaching almost 60% of the volume in the 21.0-28.9" class, and almost 50% of

29+" trees. Red and other oaks are virtually non-existent in that largest diameter class, suggesting high harvest or mortality rates for those species.

Table 5. Timberland area by forest-type group and size class, Lower Worcester Plateau ecoregion.

Forest type	Sawtimber	Poletimber	Seedling /Sapling	Total	%
Pine types	42,905	1,626	3,064	47,595	10.7%
Oak/Pine	38,423	6,381	0	44,804	10.1%
Oak/Hickory	148,351	25,513	0	173,864	39.1%
Elm/Ash	0	11,327	0	11,327	2.5%
Maple/Beech/Birch	78,747	71,133	7,017	156,897	35.2%
Aspen/Birch	10,716	0	0	10,716	2.4%
Total	319,142	115,980	10,081	445,203	100.0%
Percent of Total	71.7%	26.1%	2.3%		

Hardwoods dominate the ecoregion forest, both in numbers of trees (72% vs. 28% softwoods), and volumes of growing-stock (67% vs. 33%); this is similar to conditions statewide (Figure 19). Sawtimber volumes are closer, with hardwoods comprising 57% of the total (vs. 43% for softwoods). White pine accounts for 80% and 84% of growing-stock and sawtimber volumes, respectively, for softwoods. Northern red oak (28% and 35%) and red maple (27% and 23%) are the dominant hardwood species, both for growing-stock and sawtimber volumes. Volumes of both white pine and northern red oak in the ecoregion are significantly higher than statewide figures (Figure 20). Virtually all of the oak volume is in pole or sawtimber size classes (Table 5).

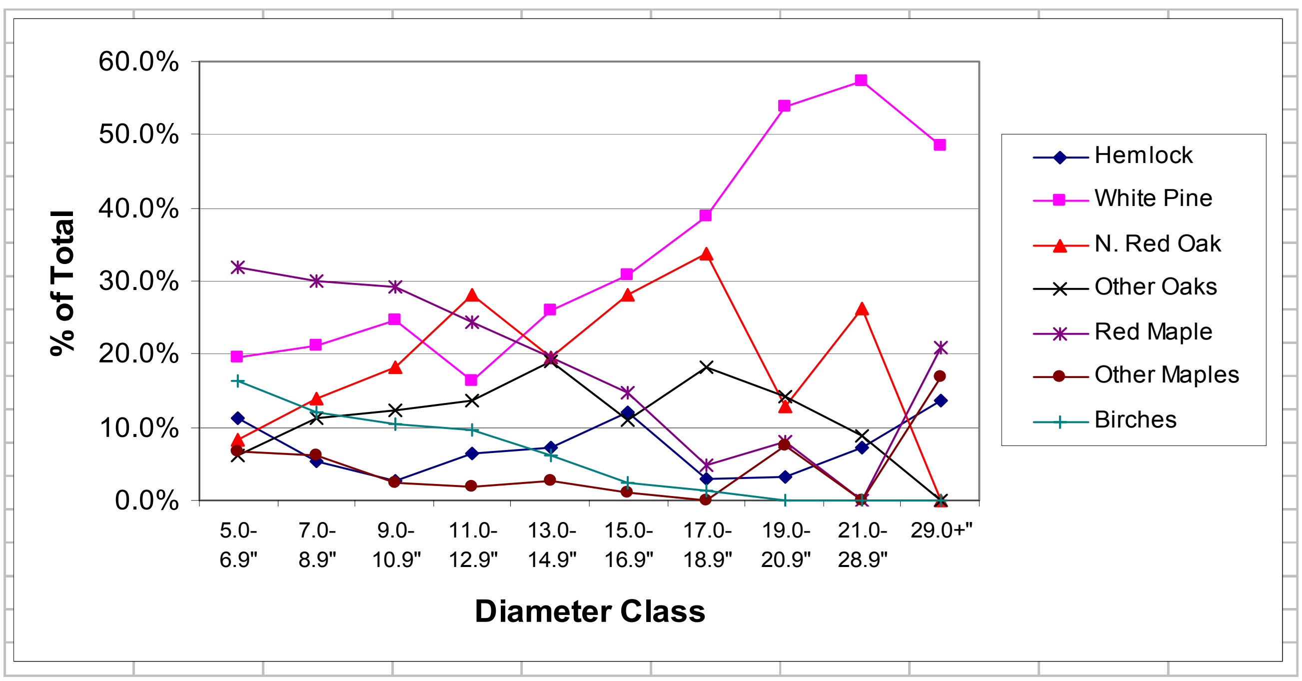

Figure 18. Growing stock volumes by diameter class for selected species in the LWP ecoregion.

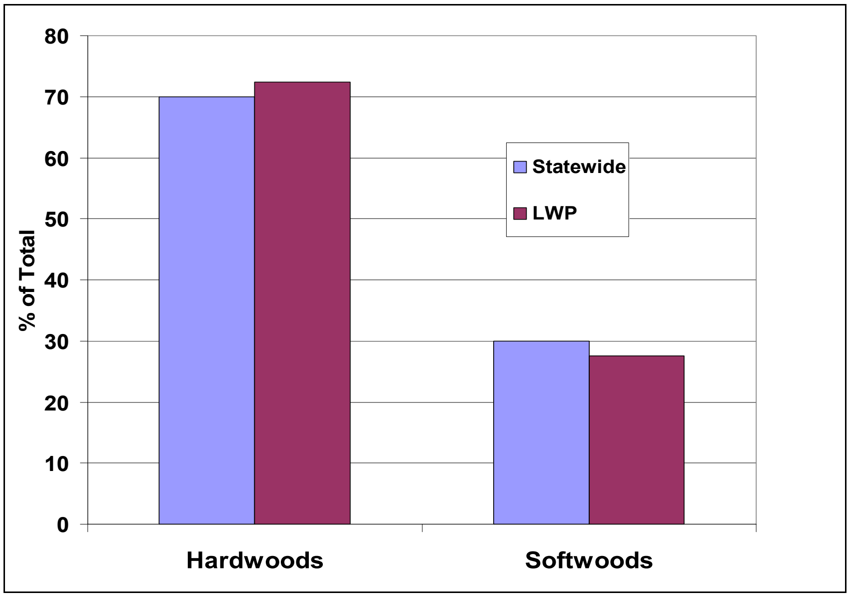

Figure 19. Hardwoods and softwoods as percentages of live trees in the Lower Worcester Plateau ecoregion and statewide.

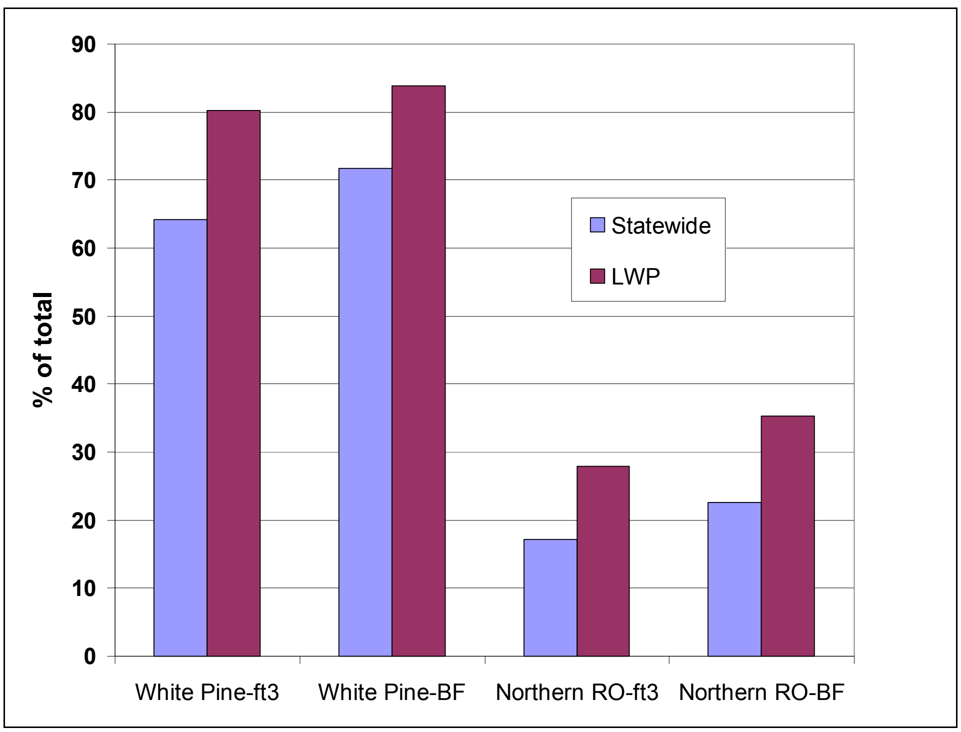

Figure 20. Comparisons of white pine and northern red oak volumes (as percent of total softwood or hardwood volumes) for the Lower Worcester Plateau ecoregion and statewide.

Comparisons of the 1984 and 1997-98 FIA data allows for calculations of average annual growth and removals for individual tree species (Table 6). Overall, growth across the ecoregion during this period averaged 161.5 board feet (BF) per acre of timberland (62.1 BF of softwoods and 99.4 BF of hardwoods). White pine represented more than 76% of the softwood growth and 29% of the total growth, while northern red oak and red maple accounted for almost half of the total hardwood growth and 28% of the total growth. Statewide, growth averaged 147.6 BF (65.3 softwoods; 82.3 hardwoods).

Removals averaged only 22.3 BF per acre of timberland, or 13.8% of growth. Northern red oak accounted for 53% of the total removals in the ecoregion, with lower amounts of other red oaks (23%), hemlock (12%) and white pine (7%) also being removed. Hardwoods accounted for more than 81% of total removals (versus 61% statewide).

Expressed as percentage of growth, just over 18% (37% statewide) of hardwood growth was removed, compared to less than 7% (30% statewide) of softwood growth. By species, removals accounted for 67% of hemlock growth (7% statewide), 59% of other red oak growth (55% statewide), 34% of northern red oak growth (58% statewide), 16% of black cherry growth (2% statewide) and 3% of white pine growth (39% statewide). Of the total removals from the ecoregion, 82% were related to timber harvest, and 18% from landuse changes.

The temporal and spatial patterns, as well as the types of timber harvest operations in the ecoregion can have a major influence on various ecological processes and characteristics, including nutrient cycling, habitat quality, and forest dynamics. However, with so much of the region controlled by private landowners, it is difficult to obtain an accurate picture of these impacts. One study conducted in the northern portion of the ecoregion (Kittredge et al. 2003) analyzed 17 years worth of timber harvest data gathered for regulatory purposes, and found some surprising results. For example, selective removals of commercially valuable trees were the predominant form of harvest, which on average occurred over 1.5% of the region annually. Approximately one-fourth of average stand volume was removed in those operations. The authors concluded that this regime of timber harvesting (more than 64% of which occurred on private lands) was exerting a major influence on forest composition, dynamics and habitat quality in the region.

Forest Disturbance Agents

Disturbance is a natural – even necessary - process in forest ecosystems. In addition to timber harvest activities, forests in this ecoregion are affected by a number of other disturbance agents, including storm events (wind, ice, etc.), insects, diseases, and others. The state Bureau of Forestry, through its Forest Health Program, generally monitors forest stress factors that might be causing declines in the forest resource. This is done with both aerial and ground-based surveys. As an example, from 1990 through 1997, these surveys documented almost 200 separate instances of forest decline on more than 109,000 acres in the ecoregion (Table 7). It should be noted however, that some of these were repeat damage in the same forest stands. By far, the major agent of this damage was the Gypsy Moth *(Lymantria dispar),* which accounted for more than 91% of the affected acreage.

Hemlock Woolly Adelgid

Since its arrival in Massachusetts in the late 1980s, significant concern has been expressed about the present and potential future impacts of the hemlock woolly adelgid (*Adelges tsugae*). HWA has already devastated thousands of acres of hemlock in other parts of the northeast, and has recently spread throughout Massachusetts. Where hemlock comprises a major portion of forest stands, mortality rates can been very high. The USDA Forest Service website on HWA is an excellent starting point for understanding the biology and distribution of this pest, and provides links to many other related sites: http://www.fs.fed.us/na/morgantown/fhp/hwa/ .

The hemlock woolly adelgid is a small aphid-like insect native to Japan. It arrived in North America in the 1920s, and was first recognized on the east coast of the US in 1951 and in Connecticut in 1985. It is gradually spreading in all directions across the range of eastern hemlock (*Tsuga canadensis)*. It is a serious pest on both eastern hemlock and Carolina hemlock (*Tsuga caroliniana* Engelm), but does not seriously injure the western hemlocks (*Tsuga heterophylla* or *Tsuga mertensiana*).

Eastern hemlock grows throughout the ecoregion, but data on its distribution are incomplete. On the watersheds under care and control of the DCR/Division of Water Supply Protection (Quabbin and Wachusett Reservoirs, and Ware River), hemlock is concentrated in three forest types: relatively pure hemlock stands; in mixes where white pine dominates; and in mixes where hardwoods dominate. Forest typing completed in the past several years indicates that out of the approximately 58,000 acres of Quabbin watershed forest that DWSP controls, 1,642 acres (~3%) is in pure hemlock stands and an additional 5,434 acres (~9%) is in stands with a significant component of hemlock in mixes with other softwood and hardwood species. About 9% of the overall basal area on Quabbin permanent inventory plots was in hemlock in 2000, and hemlock sawlog volume based on those plots was approximately 30-35 million board feet. On DWSP properties on the Ware River watershed, about 7% of the overall stocking is in hemlock, the vast majority of which is in mixed white pine/hemlock stands, which total approximately 4,325 acres. A rough estimate puts the hemlock volume at Ware River in excess of 10 MMBF. Hemlock is < 2% of the stocking, on just over 120 acres of hemlock/hardwood type on the Wachusett Reservoir watershed. A significant portion of the hemlock stocking on these watersheds is located on wet soils, on steep slopes, or in riparian zones, some of which are steep-sided ravines, while other stands are on drier and flatter terrain.

The hemlock woolly adelgid is a particularly troublesome pest for several reasons:

1. The insect is without natural enemies in the northeastern US. Several potential biocontrols have been imported from Japan and China, reared in laboratories, and released at HWA sites, but to date these have had very limited impact for a variety of reasons. Successful chemical controls are mostly limited to systemics and dormant oil spraying. These can be effective in ornamental plantings, but are virtually impossible to apply in an extensive forest infestation.
2. The HWA is parthenogenic, which means that every adult is capable of reproduction. Each adult lays 50-300 eggs, typically about 100. Furthermore, the population successfully completes two generations within a year. The first eggs are laid in March and April. Crawlers hatch from these eggs and begin feeding at the base of needles, where they remain throughout development. This generation matures in mid-June, when adults lay eggs again. These hatch in July, move to new hemlock growth and then become dormant until October, when they begin feeding again. They continue feeding throughout the winter (the species evolved in high elevations in Asia and tolerates low temperatures), maturing by spring to begin the process again.
3. While hemlocks that are under attack eventually become incapable of supporting the infestation, resulting in a population crash in the HWA on that tree, these trees are also incapable of recovering from this level of damage. Trees that are infected may die within 4-5 years, although some may persist for longer in a weakened condition. The insect attacks all ages of trees, and in fact prefers younger foliage. Research by Harvard Forest ecologists and others indicates there is so far no clear evidence of resistance sufficient to allow any individual eastern hemlock tree to survive once infested with the hemlock woolly adelgid.
4. Where hemlock dominates the riparian zone along streams, HWA mortality is of particular concern. Loss of this overstory may present short-term threats to water quality and the aquatic ecosystem by raising stream temperatures and through nitrogen losses following increases in nitrogen mineralization and nitrification rates. Regeneration of the riparian zone regulates nutrient losses to stream water and will eventually restore temperature regulation, although not to the extent formerly provided by dense, evergreen hemlock cover.

5. From a biological diversity perspective, the loss of hemlock-dominated habitats can have important effects on a variety of wildlife. The importance of this dense cover as winter habitat for large ungulates (moose, deer) has been well-documented. The black-throated green warbler, Blackburnian warbler, and Acadian flycatcher are all very strongly associated with dense hemlock forests. A variety of amphibians benefit from the cool, moist conditions associated with dense, dark hemlock forests.

Managers of state and private properties throughout the northeast are working to develop strategies to react to and regulate the effects of HWA. Practices that have been used to varying degrees of success include chemical and biological controls.

1. Chemical control uses insecticidal soaps and/or horticultural oils on foliage, or soil drenching or injection with imidacloprid. Due to cost and the difficulty of application, these controls are usually limited to small, accessible areas of particular value, generally in landscaped settings. Some organizations have considered using chemical controls to establish hemlock refugia, from which hemlock might repopulate the surrounding forest once the HWA infestation has passed through.
2. Biological control involves releasing known insect predators of the HWA, imported from Asia and reared in labs prior to release. Researchers have been experimenting with *Scymnus* and *Pseudoscymnus* lady beetles and the *Diapterobates humeralis* mite. In Massachusetts, one of the most followed releases was in Hemlock Gorge, a 23-acre park along the Charles River, for which legislation was passed to fund the rearing and release of *Pseudoscymnus* beetles. 10,000 beetles were released in 2001 and their impact is yet to be thoroughly documented. There has been some concern about the unintended ecological effects of releasing imported biocontrols, so research continues on both the direct effects on HWA and the potential impacts on native invertebrates. In addition to insect predators, research is underway to try to discover fungi that may reduce HWA success.

Given the likelihood of severe losses in hemlock stands, land managers have also responded with extensive salvage cutting. Some of this is initiated after infestations are apparent, while some is done in anticipation of infestations, usually in order to take advantage of market opportunities or to avoid price declines associated with market surpluses in a region badly infected with HWA. Research at Harvard Forest indicates that heavy cutting of stands that were not yet infected results in significantly greater decomposition of organics and accumulations of inorganic nutrients in soil water than in stands that gradually died and regenerated. These effects are likely short-term and there is not yet direct evidence that the pooled nutrients find there way to adjacent surface waters. Regeneration of these cut stands will reincorporate released nutrients through biomass accumulation.

There are many ecological factors to consider in making decisions regarding hemlock salvage. There is wide variety in the longevity of individual trees following HWA infestation, and some trees seem to persist for a long time with no sign of having become infected. If there is genotypic resistance to HWA, salvage harvesting in advance of an infestation runs the risk of removing trees that may have survived or at least persisted for a long time. A decision to try to replace hemlock by cutting and planting to a species with similar characteristics is problematic. Hemlock is the only native Massachusetts tree species that produces dense, shade-tolerant foliage with deep, acidic duff layers and cool, moist, depauperate understories. Non-native plantings such as Norway spruce may imitate hemlock stand conditions, but it appears likely that most hemlock stands in Massachusetts will naturally regenerate to a mix of native species, predominantly black birch, following either salvage cutting or HWA mortality.

Table 6. Average annual growth and removal of sawtimber volume (in board feet) from the Lower Worcester Plateau ecoregion and statewide, 1984-1998.

	Statewide							LWP						
Species	growth	growth per acre of timberland (BF)	% of total growth	removals	removals per acre of timberland (BF)	% of total removals	removals as % of growth	growth	growth per acre of timberland (BF)	% of total growth	removals	removals per acre of timberland (BF)	% of total removals	removals as % of growth
Hemlock	46862	17.8	12.1%	3147	1.2	2.4%	6.7%	1789	4.0	2.5%	1201	2.7	12.1%	67.1%
White Pine	111310	42.3	28.7%	43469	16.5	32.9%	39.1%	21048	47.3	29.3%	678	1.5	6.8%	3.2%
Pitch Pine	1753	0.7	0.5%	3307	1.3	2.5%	188.6%	120	0.3	0.2%	0	0.0	0.0%	0.0%
Red Pine	-333	-0.1	-0.1%	826	0.3	0.6%	-248.0%	208	0.5	0.3%	0	0.0	0.0%	0.0%
Spruce	8509	3.2	2.2%	1103	0.4	0.8%	13.0%	4429	9.9	6.2%	0	0.0	0.0%	0.0%
Others	3819	1.5	1.0%	0	0.0	0.0%	0.0%	33	0.1	0.0%	0	0.0	0.0%	0.0%
All Softwoods	*171920*	*65.3*	*44.3%*	*51852*	19.7	*39.2%*	30.2%	*27627*	62.1	*38.4%*	*1879*	4.2	*18.9%*	6.8%
Red Maple	43978	16.7	11.3%	6731	2.6	5.1%	15.3%	5170	11.6	7.2%	0	0.0	0.0%	0.0%
Sugar Maple	4824	1.8	1.2%	1224	0.5	0.9%	25.4%	2721	6.1	3.8%	0	0.0	0.0%	0.0%
Yellow Birch	5133	2.0	1.3%	13865	5.3	10.5%	270.1%	24	0.1	0.0%	0	0.0	0.0%	0.0%
Sweet Birch	12367	4.7	3.2%	1609	0.6	1.2%	13.0%	4178	9.4	5.8%	0	0.0	0.0%	0.0%
Paper Birch	6135	2.3	1.6%	458	0.2	0.3%	7.5%	622	1.4	0.9%	0	0.0	0.0%	0.0%
Hickory	5166	2.0	1.3%	1255	0.5	0.9%	24.3%	2047	4.6	2.8%	0	0.0	0.0%	0.0%
Beech	5057	1.9	1.3%	775	0.3	0.6%	15.3%	-286	-0.6	-0.4%	0	0.0	0.0%	0.0%
White Ash	16055	6.1	4.1%	2514	1.0	1.9%	15.7%	3644	8.2	5.1%	0	0.0	0.0%	0.0%
Aspen	9390	3.6	2.4%	369	0.1	0.3%	3.9%	289	0.6	0.4%	0	0.0	0.0%	0.0%
Black Cherry	19454	7.4	5.0%	427	0.2	0.3%	2.2%	2761	6.2	3.8%	427	1.0	4.3%	15.5%
White Oak	5542	2.1	1.4%	3717	1.4	2.8%	67.1%	3535	7.9	4.9%	237	0.5	2.4%	6.7%
N. Red Oak	47750	18.1	12.3%	27541	10.5	20.8%	57.7%	15337	34.4	21.3%	5169	11.6	52.0%	33.7%
Other Red Oaks	27809	10.6	7.2%	15180	5.8	11.5%	54.6%	3791	8.5	5.3%	2237	5.0	22.5%	59.0%
Elm	512	0.2	0.1%	484	0.2	0.4%	94.5%	334	0.8	0.5%	0	0.0	0.0%	0.0%
Other hardwood	7334	2.8	1.9%	4309	1.6	3.3%	58.8%	105	0.2	0.1%	0	0.0	0.0%	0.0%
All Hardwoods	*216506*	82.3	55.7%	*80458*	30.6	60.8%	37.2%	*44272*	99.4	61.6%	*8070*	18.1	81.1%	18.2%
All Species	388426	147.6	100.0%	132310	50.3	100.0%	34.1%	71899	161.5	100.0%	9949	22.3	100.0%	13.8%

Table 7. Forest damage agents in the Lower Worcester Plateau ecoregion, 1990-1997.

AGENT OR OBSERVATION	COUNT	ACRES	% OF TOTAL
Beech Maple	1	58.3	0.05%
Birch	2	232.5	0.21%
Birch Leaf Miner	2	478.2	0.44%
Cherry Scallop Shell Moth	7	682.9	0.62%
Dead Hemlock	3	266.1	0.24%
Dead Trees	2	94.1	0.09%
Dead Trees (Flooded)	1	48.7	0.04%
Drought	2	175.6	0.16%
Gypsy Moth	130	99945.3	91.44%
Hemlock Looper	4	681.8	0.62%
Larch Sawfly	1	207.6	0.19%
Logging	4	605.0	0.55%
Oak Leaf Skeletonizer	10	1432.9	1.31%
Off Color	2	206.1	0.19%
Unknown	22	4182.4	3.83%
Totals:	193	109297.3	100.00%

V. Soil and Water Conservation

The Lower Worcester Plateau ecoregion contains abundant public water supplies. In addition to the 25,000 acre Quabbin Reservoir – one of the largest unfiltered public drinking water reservoirs in the country – the state Department of Environmental Protection (DEP) monitors 390 public water supply sources in the ecoregion (Figure 21). These include 35 surface water reservoirs and 146 public ground water wells. More than 229,000 acres (34% of the ecoregion) are considered Outstanding Resource Waters (ORWs) (Figure 22). Further, almost 20,000 acres (approximately 3%) of high or medium yield aquifers underlie the ecoregion (Figure 23). Most of these occur in the sand and gravel deposits within the ecoregion, which comprise approximately 20% of the total area (Figure 24 and Table 8).

Most of the ecoregion lies within the Chicopee River watershed, although portions also drain to the Connecticut, Nashua, Millers, Blackstone, French and Quinebaug rivers (Figure 5). In addition to the major rivers, an abundance of lakes, ponds, wetlands and streams also occur in the ecoregion (Figure 25). This is especially true in the southeastern portion of the region, where many waterbodies dot the landscape. Most of these waterbodies have predominantly forested watersheds.

No data is available on the impacts on soil and water conditions in the ecoregion. However, anecdotal information and observations indicate that uncontrolled off-road vehicle use is a serious problem in portions of the ecoregion. Further, inter-basin transfers (e.g., from the Quabbin Reservoir to metropolitan Boston), significant increases in developed land in portions of the ecoregion, and impacts associated with specific landuses (e.g., agriculture) or point-source discharges may pose threats to instream flows, water quality and/or soil conservation.

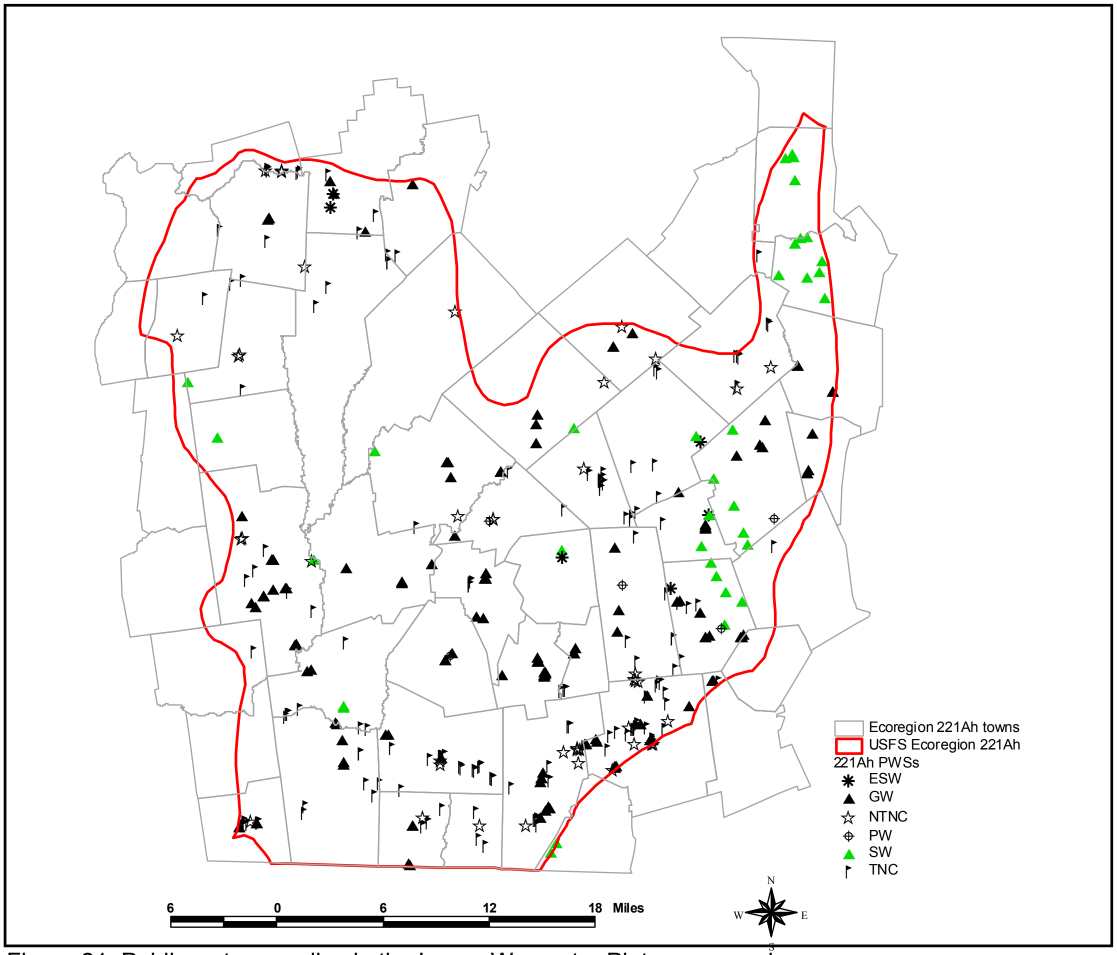

Figure 21. Public water supplies in the Lower Worcester Plateau ecoregion.

Table 8. Surficial geology in the Lower Worcester Plateau ecoregion.

Type	Acres in Ecoregion	% of Ecoregion
Sand and Gravel	134,270	19.7
Till or Bedrock	534,149	78.4
Fine-grained deposits	365	0.0
Floodplain Alluvium	12,848	1.9

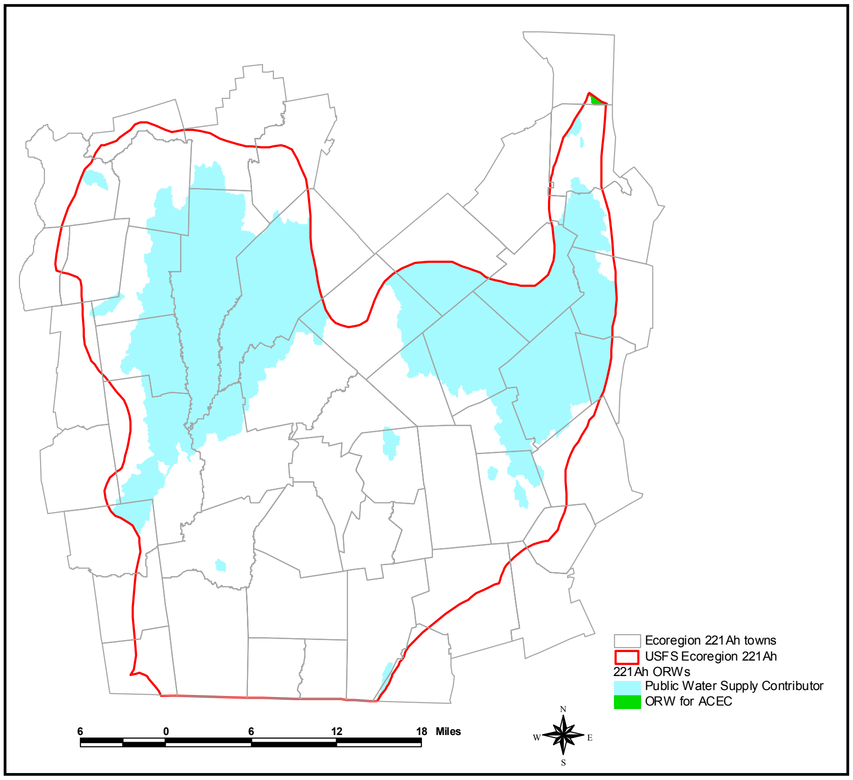

Figure 22. Outstanding Resource Water (ORW) areas in the Lower Worcester Plateau ecoregion.

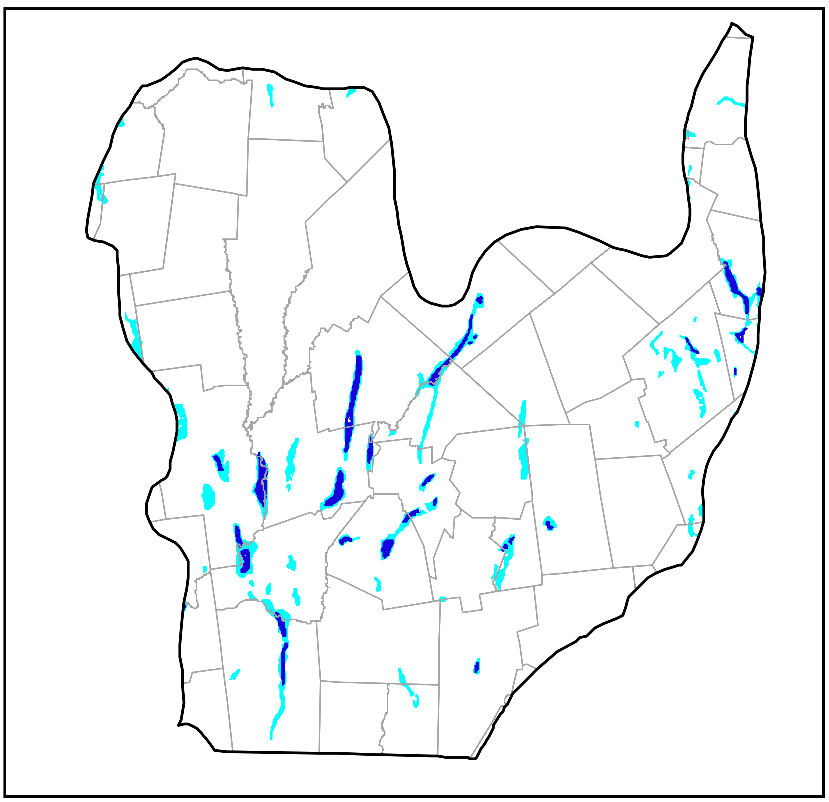

Figure 23. High (darker color) and medium-yield aquifers in the Lower Worcester Plateau ecoregion.

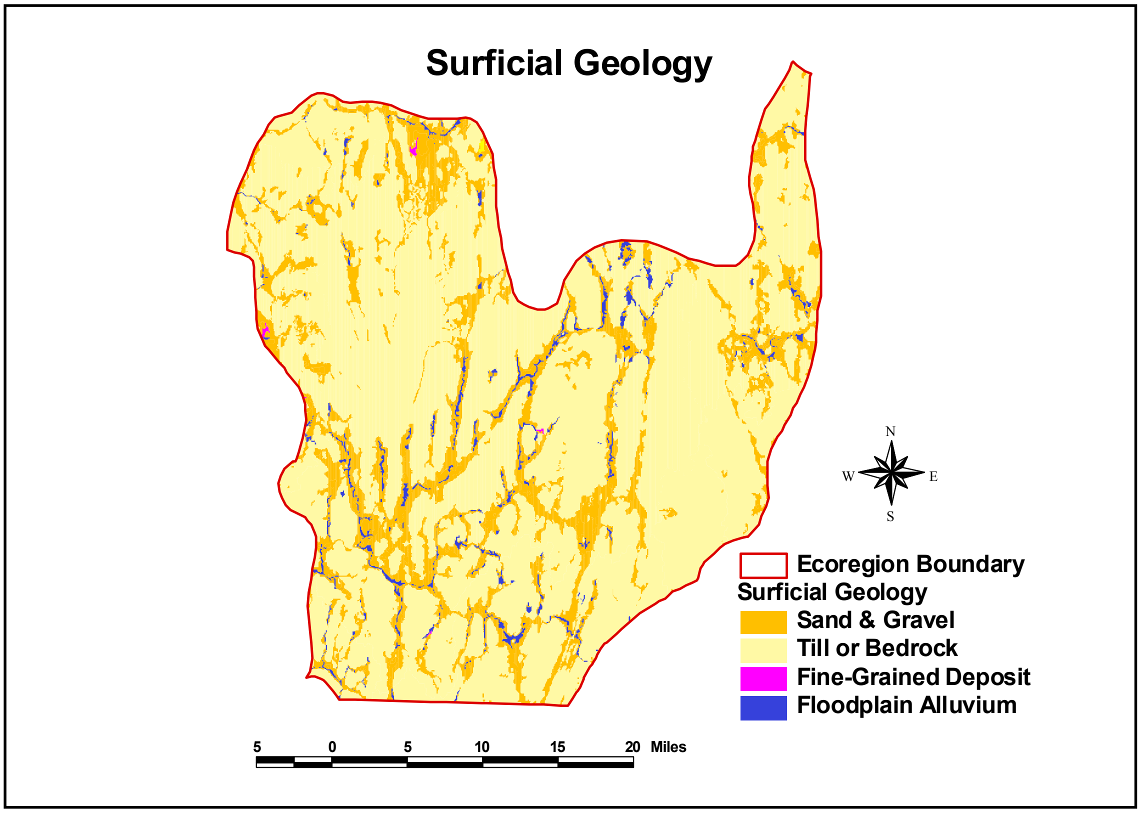

Figure 24. Surficial geology of the Lower Worcester Plateau ecoregion.

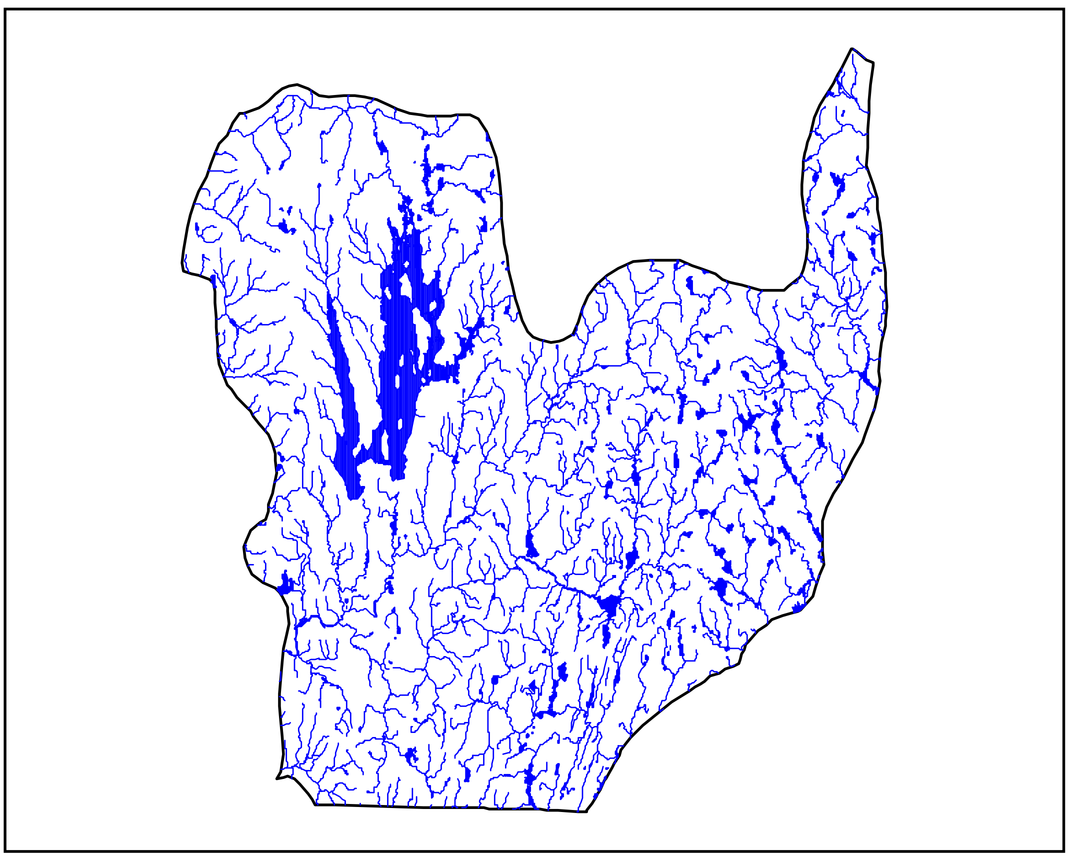

Figure 25. Hydrology of the Lower Worcester Plateau ecoregion.

VI. Regional and Global Considerations

The participants in the Montreal Process recognized the essential role that forested ecosystems play in the long-term well-being of local populations, national economies and the earth's biosphere as a whole. Thus, while individual forest management plans address the conditions and needs of specific properties, those plans should be developed in the context of larger systems. This is the basis for development of these ecoregional guidance documents, but even those must consider larger regional and even global considerations.

For example, much has been written in recent years about the role of forests in "tying up" or sequestering carbon, primarily by absorbing carbon dioxide. This in turn plays a major role in reducing concentrations of greenhouse gases in the atmosphere – considered to be a primary cause of global warming. This important role of forests appears to be influenced by the age and other conditions of forest stands (e.g., younger, faster-growing trees tend to sequester more carbon than older mature trees). Our understanding of carbon cycling and its significance in the environment is still incomplete, thus no specific management goal related to carbon sequestration will be presented. However, we'll continue to monitor new developments in the area, and develop or modify individual land management plans accordingly.

Across the globe, there are numerous examples of the vital role that forested watersheds play in protecting drinking water supplies (Dudley and Stolton, 2003). Some of these watersheds are far-removed from the population centers that rely on the water they provide. At the Quabbin Reservation, in the north-central portion of the LWP ecoregion, the DWSP actively manages the forested lands surrounding the reservoir to produce and maintain a "protection forest" that will be resilient and resistant to major disturbances that could potentially impact water quality. This protection forest will include a diversity of species as well as age classes across the watershed.

The protection of drinking water supplies, and of water quality in general, is also a function of the land uses within the corresponding watersheds. The best water quality generally originates from undeveloped vegetated areas where rainwater is able to percolate into the ground, and overland flow is minimized. Different land uses or cover types vary in their "permeability", ranging from the highly permeable (e.g., undisturbed forests) to highly impervious (e.g., asphalt parking lots). Using permeability values developed by DEP and MassGIS, it was estimated that the overall imperviousness of the ecoregion is approximately 3.5% (Table 9). Previous research has concluded that water quality problems tend to arise when imperviousness approaches 10% (Center for Watershed Protection, 1998).

Land use data can also be used to estimate pollution loading, and models have been developed to calculate nitrogen, phosphorus and suspended solids based on land uses within particular drainage areas. However, it should be noted that ecoregion boundaries are not consistent with watershed boundaries, so the methods used to estimate imperviousness and pollution loadings are not directly applicable to the ecoregion as a whole. Still, the general relationships still apply, and provide another example of why a larger perspective is often needed – water draining from the Lower Worcester Plateau ecoregion feeds at least 10 major rivers in the state, potentially transporting nutrients and pollutants into other ecoregions.

Finally, the more than ¼ million people that live in the LWP ecoregion consume large quantities of energy, the vast majority of which is generated elsewhere. Sustainability principles call for more local production of the products and energy supplies. At present, it is estimated that most of the forest products harvested in this ecoregion are exported out of the region, while the resources needed by its residents are imported.

Table 9. Imperviousness estimates in the LWP ecoregion.

Landuse	Acres	Imperviousness coefficient	Impervious acres equiv.
Cropland	27,859	0.01	279
Pasture	15,289	0.01	153
Forest	484,835	0.01	4,848
Wetland	12,632	0.01	126
Openland	1,901	0.01	19
Mining	14,493	0.01	145
Recreation	3,517	0.02	70
Multi-Residential	982	0.8	785
High Residential	6,869	0.57	3,915
Med. Residential	16,864	0.13	2,192
Low Residential	40,847	0.1	4,085
Commercial	2,407	0.9	2,166
Industrial	2,216	0.75	1,662
Urban Open	4,495	0.01	45
Tranportation	3,657	0.75	2,743
Water Disposal	1,020	0.01	10
Water Disposal	39,188	0.01	392
Woody Perennial	2,564	0.01	26
Totals	681,633		23,661
Overall Percent Imperviousness =			**3.5%**

VII. Socio-Economic Factors

The management of natural resources is as much a social issue as a scientific one. While science is used to achieve management goals, it is human values and other sociological considerations that define those goals. The participants in the Montreal Process recognized this when they stated that "*…an informed, aware and participatory public is indispensable to promoting the sustainable management of forests".* Accordingly, the development of both the ecoregional guidance documents, and the specific land management plans, will involve substantial opportunities for public input and involvement. Further, assessments of other socio-economic data will be conducted to shed further light on the social aspects of forest management.

<u>Demographics and Forestland Ownership</u>

The estimated population (based on the 2000 U.S. Census) of the LWP ecoregion is 265,000. Population estimates for the 51 communities in the ecoregion range from 927 to 172,000 (Table 10 and Figure 26). Many of these communities are small towns (almost half of the LWP communities have populations of less than 5,000). The highest population densities are along the edges of the ecoregion (Figure 26). As is typical of small rural communities, residential development is often dispersed across the landscape meaning that many residents live in close proximity to (and often surrounded by) the forest. This results in a different relationship to, and an understanding and appreciation of, the natural world than is typical of more urban dwellers.

On average, communities in this ecoregion grew by just over 21% from 1980 to 2000 (versus a statewide average of 18%). Overall, population growth in the 51 communities was just over 12% (Table 10). Growth in 5 ecoregion communities exceeded 50%, with one community exceeding 106% growth (this represented the 3rd highest growth rate in Massachusetts during that time period). Only one community (Fitchburg) experienced negative growth during that period (Figure 27).

The amount of developed land in the 51 communities in the Lower Worcester Plateau ecoregion increased by approximately 49% from 1971 to 1999 (Table 11), with 10 communities experiencing greater than 100% increases. In general, the communities with the highest increases in developed land were those that also experienced the greatest population growth during that time period (see Figures 27 and 28). Many of these communities are located in the eastern and middle portion of the ecoregion.

Build-out analyses conducted by EOEA several years ago indicate that the population in the 51 ecoregion communities could more than double if all available buildable land was developed. Overall, ecoregion communities could see population increases averaging 121%. However, while some communities have relatively little potential for future population growth, several could see increases of more than 1000% (Figure 29 and Table 10).

One result of the recent population growth and development trends is the further subdivision of large forested tracts into smaller units. Approximately 29% of the forestland in the LWP ecoregion is publicly-owned. While this is somewhat higher than the state as a whole (in which about 24% is publicly-owned (Petersen, 2000)), it still leaves a substantial acreage that is in private ownership. While data specific to this ecoregion is limited, it is clear from the data that does exist, along with personal observations and experiences, that the blocks of privately-owned forested land in the LWP ecoregion are following the statewide trends of subdivision of large parcels into more smaller ones.

In Massachusetts, it has been estimated that the number of landowners with fewer than 50 acres of timberland has more than doubled since 1973 (USFS, 2002). This can have a strong influence on how our forestland is managed, since owners of relatively small blocks of forest are less likely to manage it for forest products, and are also more reluctant to allow others on their land for hunting, fishing and other recreational activities (USFS, 2002)

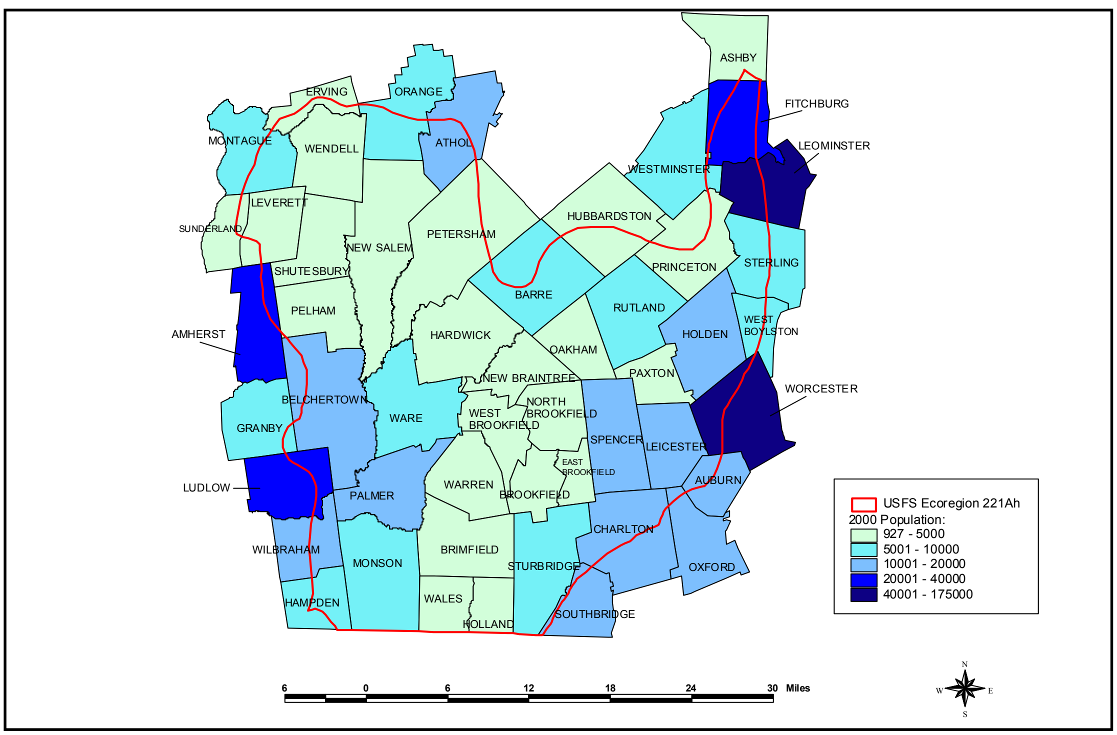

Figure 26. Population estimates for Lower Worcester Plateau communities.

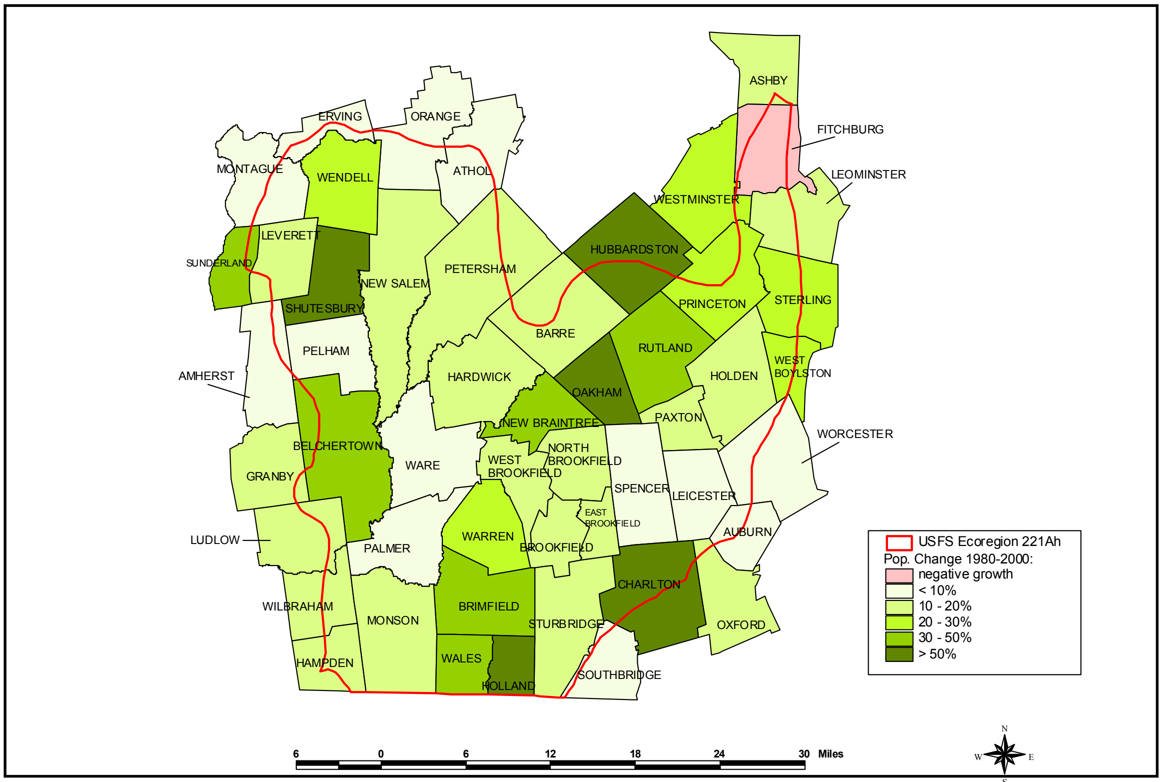

Figure 27. Population change in Lower Worcester Plateau communities, 1980-2000.

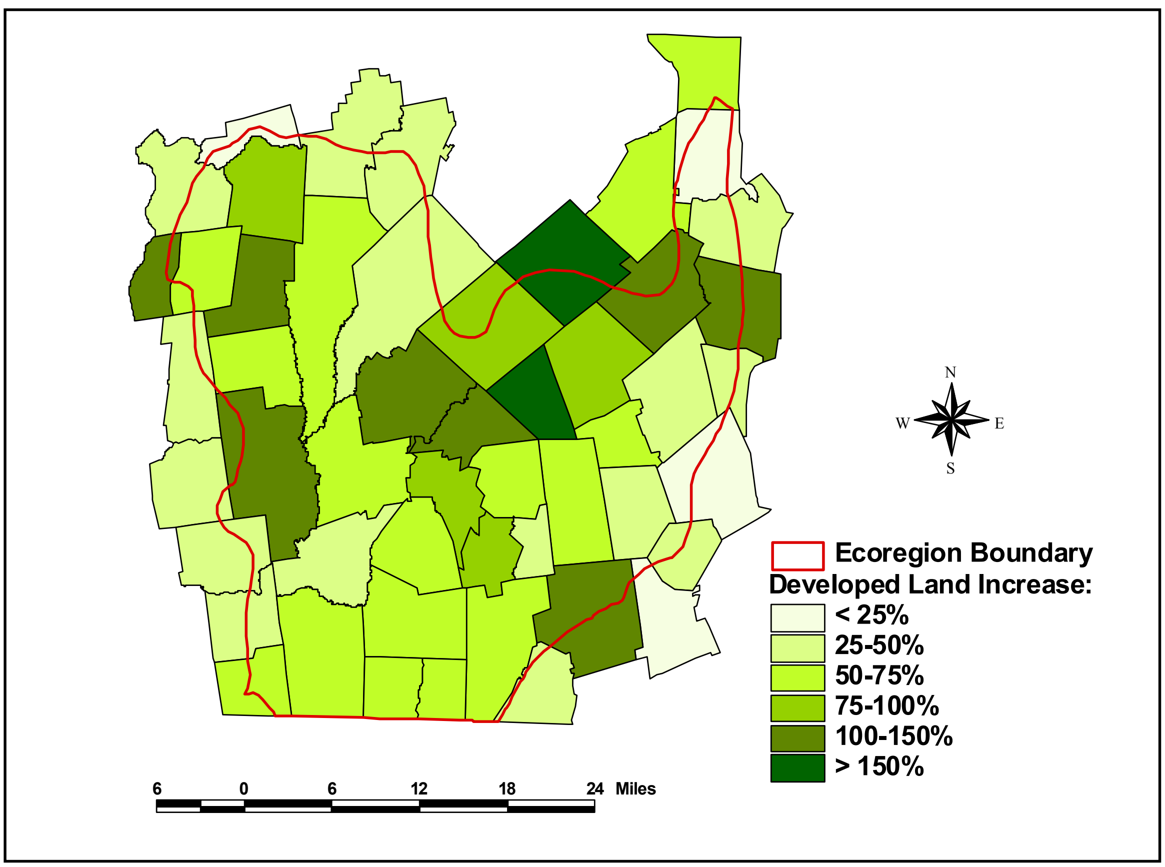

Figure 28. Increases in developed land in Lower Worcester Plateau communities, 1971-1999.

Outdoor Recreation

Outdoor recreation and tourism are important activities in the LWP ecoregion. Much of the region is rural, and the traditional outdoor sporting activities of hunting, fishing and trapping are still popular and widespread in the ecoregion. An indirect reflection of this is the fact that the Department of Fish & Game maintains 30 Wildlife Management Areas, 11 river or pond access areas, and several more public recreation sites in the ecoregion (Figure 30). The Division of State Parks and Recreation maintains 28 properties in the ecoregion, most of which also provide outdoor recreational opportunities. These include 17 state forests, and 6 state parks (Figure 31). Much of the outdoor recreation that occurs on these properties is forest or water-based.

Forest-based Industry

In addition to lumber, pulp and fuelwood, forest ecosystems provide a number of other commercial products. These include Christmas trees, maple syrup, medicinal plants, fruits, nuts, oils, mushrooms, and charcoal, among others. Further, Massachusetts' forest resources provide various non-commodity values such as habitat for wildlife, biodiversity protection, recreational opportunities, scenic landscapes, clean air, stable soil, and high quality water. While most of these values are difficult or impossible to quantify, their cumulative value is still very significant. Unfortunately, these values are often unrecognized by landowners.

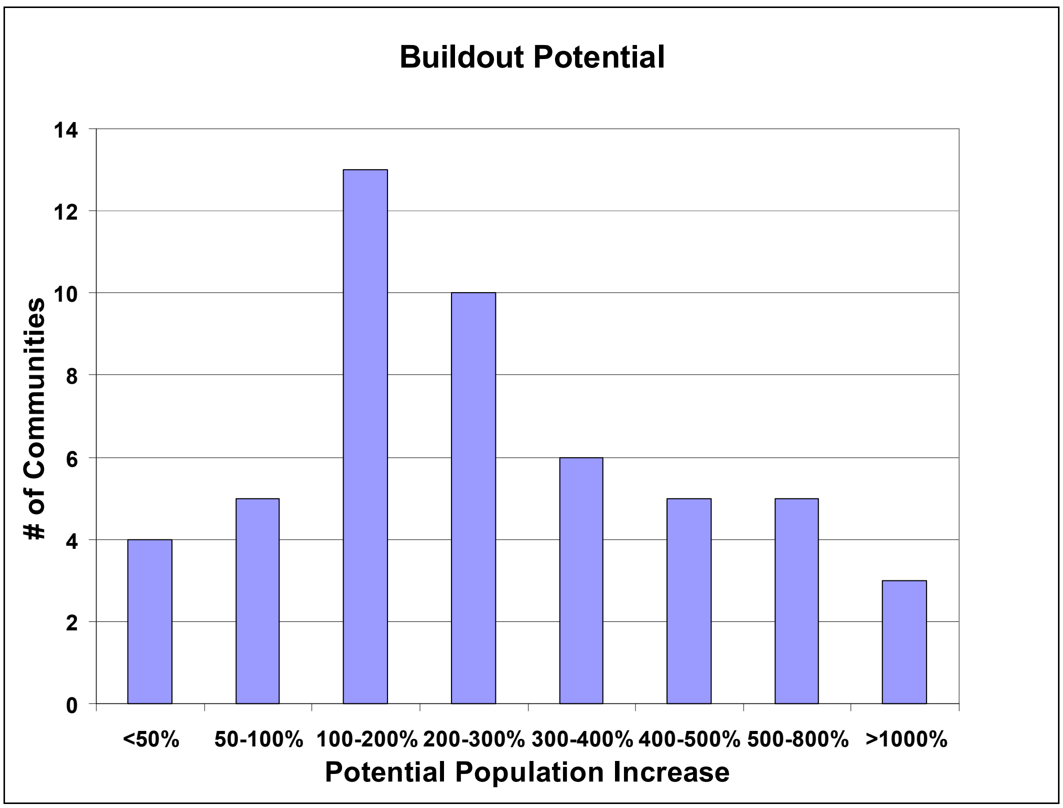

Figure 29. Potential population growth in LWP communities

Table 10. Population data for communities in the Lower Worcester Plateau Ecoregion

TOWN	1980 Population	2000 Population	% Change (80-00)	Additional population at buildout	% Change (2000-BO)
AMHERST	32804	34874	6.31%	3988	11.4%
ASHBY	2562	2845	11.05%	13823	485.9%
ATHOL	10560	11299	7.00%	28199	249.6%
AUBURN	14477	15901	9.84%	6084	38.3%
BARRE	4257	5113	20.11%	13591	265.8%
BELCHERTOWN	9012	12968	43.90%	40769	314.4%
BRIMFIELD	2458	3339	35.84%	19225	575.8%
BROOKFIELD	2543	3051	19.98%	4956	162.4%
CHARLTON	7480	11263	50.57%	20578	182.7%
EAST BROOKFIELD	1885	2097	11.25%	4500	214.6%
ERVING	1430	1467	2.59%	11718	798.8%
FITCHBURG	39740	39102	-1.61%	25799	66.0%
GRANBY	5497	6132	11.55%	22298	363.6%
HAMPDEN	4665	5171	10.85%	10606	205.1%
HARDWICK	2272	2622	15.40%	16234	619.1%
HOLDEN	13512	15621	15.61%	17696	113.3%
HOLLAND	1583	2407	52.05%	10914	453.4%
HUBBARDSTON	1891	3909	106.72%	13489	345.1%
LEICESTER	9584	10471	9.26%	13897	132.7%
LEOMINSTER	34624	41303	19.29%	16654	40.3%
LEVERETT	1479	1663	12.44%	16764	1008.1%
LUDLOW	18348	21209	15.59%	14398	67.9%
MONSON	7374	8359	13.36%	30640	366.6%
MONTAGUE	7977	8489	6.42%	15256	179.7%
NEW BRAINTREE	682	927	35.92%	4159	448.7%
NEW SALEM	780	929	19.10%	10622	1143.4%
NORTH BROOKFIELD	4175	4683	12.17%	9628	205.6%
OAKHAM	1099	1673	52.23%	4479	267.7%
ORANGE	7054	7518	6.58%	31364	417.2%
OXFORD	11891	13352	12.29%	14574	109.2%
PALMER	11756	12497	6.30%	18202	145.7%
PAXTON	3711	4386	18.19%	8526	194.4%
PELHAM	1306	1403	7.43%	5783	412.2%
PETERSHAM	997	1180	18.36%	19143	1622.3%
PRINCETON	2636	3353	27.20%	8597	256.4%
RUTLAND	4527	6353	40.34%	9922	156.2%
SHUTESBURY	1162	1810	55.77%	9953	549.9%
SOUTHBRIDGE	16629	17214	3.52%	12302	71.5%
SPENCER	11265	11691	3.78%	16109	137.8%
STERLING	5813	7257	24.84%	7761	106.9%
STURBRIDGE	6565	7837	19.38%	20998	267.9%
SUNDERLAND	2883	3777	31.01%	10488	277.7%
WALES	1326	1737	31.00%	6571	378.3%
WARE	9228	9707	5.19%	18141	186.9%
WARREN	3840	4776	24.38%	16170	338.6%
WENDELL	798	986	23.56%	5524	560.2%
WEST BOYLSTON	6063	7481	23.39%	3823	51.1%
WEST BROOKFIELD	3191	3804	19.21%	5604	147.3%
WESTMINSTER	5353	6907	29.03%	16091	233.0%
WILBRAHAM	12166	13473	10.74%	12463	92.5%
WORCESTER	159843	172648	8.01%	26487	15.3%
TOTALS	*534753*	*600034*	12.21%	*725560*	*120.9%*

Table 11. Percent change in developed land in Lower Worcester Plateau communities, 1971-1999.

TOWN NAME	% Change 1971-1985	% Change 1985-1999	% Change 1971-1999
Amherst	16.12%	13.81%	32.16%
Ashby	21.35%	29.59%	57.26%
Athol	11.27%	16.04%	29.11%
Auburn	13.37%	11.72%	26.67%
Barre	27.10%	48.54%	88.79%
Belchertown	64.60%	47.89%	143.42%
Brimfield	30.61%	27.81%	66.94%
Brookfield	22.56%	44.06%	76.57%
Charlton	46.48%	58.71%	132.47%
East Brookfield	11.38%	27.38%	41.87%
Erving	-12.21%	14.72%	0.71%
Fitchburg	8.39%	7.75%	16.80%
Granby	21.09%	22.59%	48.45%
Hampden	30.06%	20.38%	56.57%
Hardwick	27.29%	57.27%	100.19%
Holden	23.69%	12.06%	38.61%
Holland	18.53%	27.39%	51.01%
Hubbardston	49.39%	77.33%	164.92%
Leicester	9.77%	24.04%	36.15%
Leominster	21.89%	18.19%	44.06%
Leverett	38.66%	11.35%	54.40%
Ludlow	15.07%	17.82%	35.58%
Monson	23.38%	28.11%	58.06%
Montague	13.81%	14.90%	30.77%
New Braintree	45.60%	61.56%	135.22%
New Salem	23.73%	26.51%	56.52%
North Brookfield	23.13%	29.90%	59.95%
Oakham	68.14%	76.97%	197.55%
Orange	14.44%	18.21%	35.28%
Oxford	49.43%	20.14%	79.52%
Palmer	14.00%	25.41%	42.97%
Paxton	20.85%	36.50%	64.96%
Pelham	23.72%	25.17%	54.86%
Petersham	12.41%	19.79%	34.66%
Princeton	78.82%	30.30%	133.00%
Rutland	29.47%	42.31%	84.25%
Shutesbury	62.09%	31.41%	113.00%
Southbridge	15.49%	18.81%	37.22%
Spencer	31.69%	25.14%	64.79%
Sterling	78.46%	33.41%	138.09%
Sturbridge	26.87%	22.42%	55.31%
Sunderland	33.58%	57.21%	110.00%
Wales	24.11%	40.83%	74.77%
Ware	19.22%	29.77%	54.72%
Warren	16.84%	36.37%	59.33%
Wendell	55.39%	16.79%	81.48%
West Boylston	26.25%	9.69%	38.47%
West Brookfield	22.02%	45.34%	77.35%
Westminster	32.27%	24.14%	64.21%
Wilbraham	13.72%	16.83%	32.86%
Worcester	5.38%	5.66%	11.34%
Totals:	**21.31%**	**22.45%**	**48.55%**

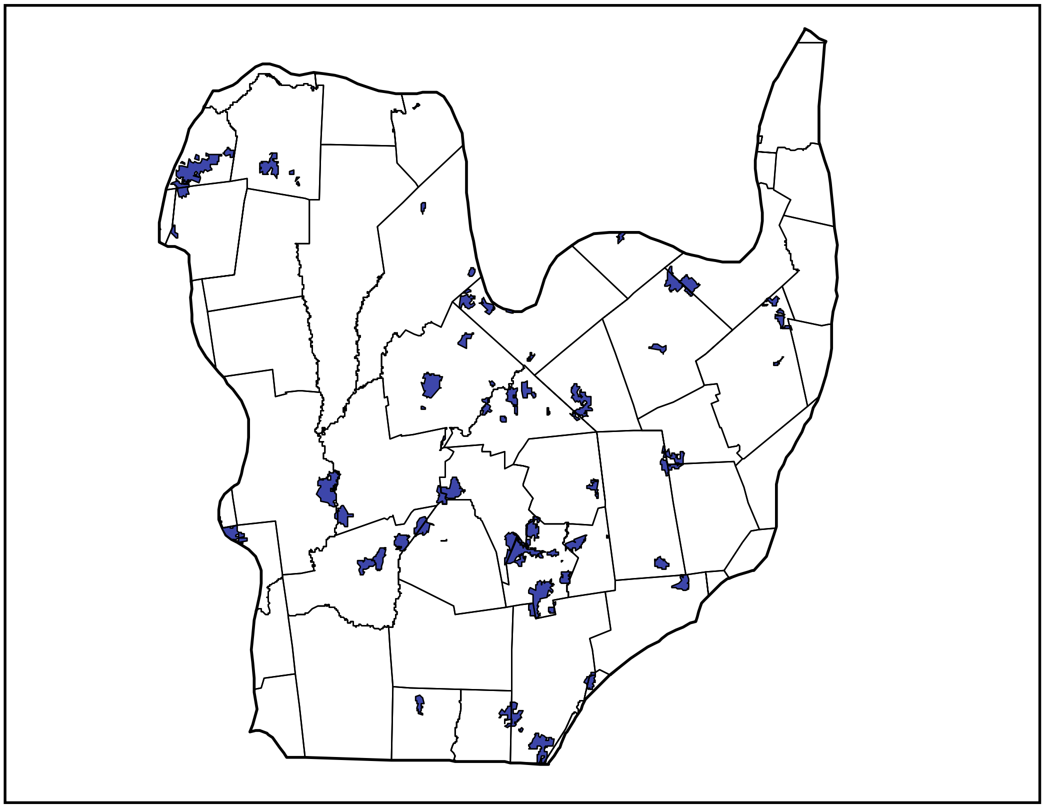

Figure 30. Locations of Department of Fish & Game properties in the LWP ecoregion.

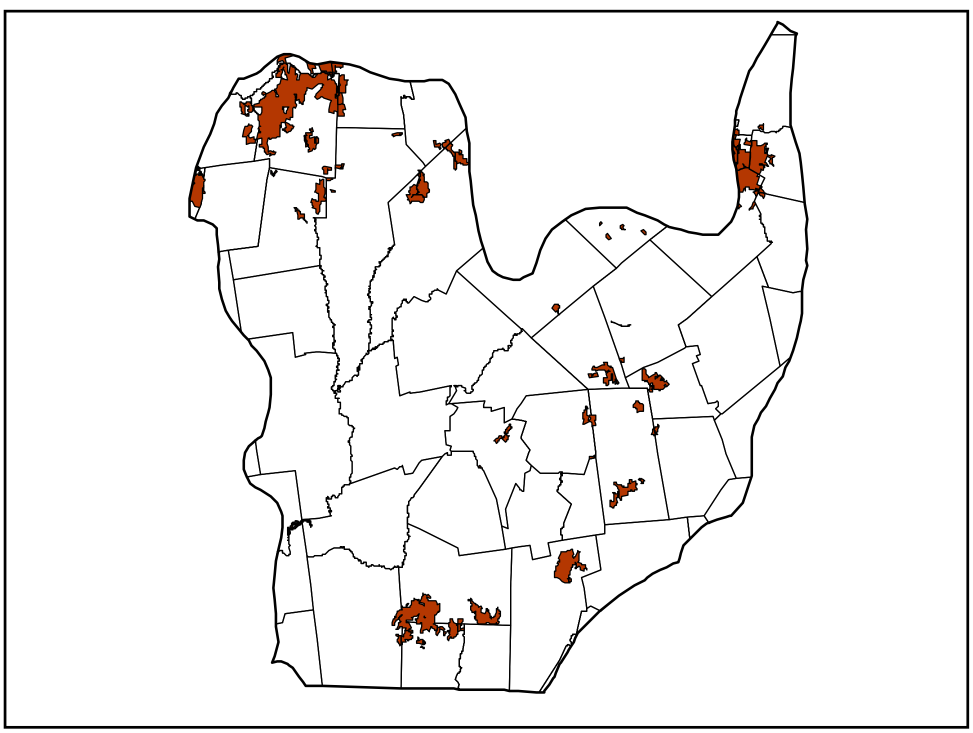

Figure 31. Locations of Division of State Parks & Recreation properties in LWP ecoregion.

The forest resources of the LWP ecoregion also support a number of jobs and local businesses, including sawmills, timber harvesters, private consulting foresters, maple sugar producers, and Christmas tree growers. Data on each of these follows. While these lists do not portray a complete picture of the forest product related commercial activity occurring in the ecoregion, they nonetheless are based on the most current, readily-available information we could find.

- *Sawmills*

There are 10 sawmills within the LWP ER, in the towns of Athol, Orange, Wendell, Ware, Amherst (2), Oakham, Charlton, and Barre (2). These are all circular sawmills, primarily offering sawing services. One mill offers kiln drying (all offer air-drying), and 3 offer planing and/or molding services. The annual production of these mills ranges from 15,000 board feet to 4,000,000 board feet, with a total for the ecoregion of 10,270,000 board feet per year. Three mills produce in excess of 1,000,000 board feet per year, and account collectively for 82% of the total annual ecoregion production (Heyes Forest Products in Athol, WD Cowls Lumber in Amherst, and Robinson Lumber in Barre). Some mills specialize in hardwoods, others in softwoods, but every commercial species in this ecoregion is milled somewhere within the region. Products from these mills include:

- Boards and long lumber
- Timbers, beams, and landscape ties
- Siding
- Quarter sawn lumber
- Dimension lumber
- Flooring
- Pallet stock
- Decking
- Log homes
- Fuel wood and chips
- Bark and sawdust

Notably absent from the ecoregion are hardwood or softwood pulp-using industries. A number of sawmills use their wood wastes for co-generation, and known commercial users of biomass for heat or energy in the region are listed below. There are many small wood-using industries and crafts producers that rely on a mix of locally produced and imported forest products. Many of the mills in this region have their own websites, and some are members of the Massachusetts Forest Products Association (www.massforest.com).

Pinetree Power Plant – Westminster
18 MW electrical generation facility with primary electrical customer being Fitchburg Gas & Elec. Co.
Uses approx 200,000 tons/ yr of wood residues as well as landfill gas from adjacent Fitchburg landfill as fuel.

Athol Table –Athol
Industrial system utilizing waste sawdust from their wood processing facilities to fuel a boiler providing steam to their dry kilns.
Size and consumption of wood fuel unknown.

Athol- Royalston High School- Athol
3 MM BTU/ HR thermal only system providing heat and domestic hot water to the 89,000 square foot building.
Uses about 400 tons/ yr of hardwood sawmill chips.

- *Timber harvesters*

There are 89 licensed timber harvesters in this ecoregion, distributed geographically throughout the region, as shown in Table 12. The highest concentration of timber harvesters list Belchertown as their home town. Timber harvesters live in 33 of the 51 towns in the ecoregion.

Table 12. Licensed timber harvesters in LWP communities.

City or Town	Total
Amherst	4
Ashby	2
Athol	5
Barre	2
Belchertown	8
Brimfield	5
Brookfield	2
Charlton	3
East Brookfield	1
Fitchburg	2
Granby	2
Hardwick	4
Hubbardston	5
Leicester	1
Monson	2
New Braintree	1
New Salem	3
Oakham	2
Orange	2
Palmer	4
Petersham	3
Princeton	1
Rutland	1
Shutesbury	1
Southbridge	1
Sturbridge	1
Sunderland	1
Wales	1
Ware	4
Warren	1
Wendell	7
West Brookfield	2
Westminster	5
Grand Total	89

- *Private consulting foresters*

There are at least 27 licensed Private Consulting Foresters living in this ecoregion, distributed geographically throughout the region, as shown in Table 13. The highest concentration of private consulting foresters list Belchertown as their home town. Foresters live in 18 of the 51 towns in the ecoregion. Many are members of the Massachusetts Association of Professional Foresters (www.massforesters.org). More information on both licensed foresters, and private consulting foresters is available at the DSPR website (www.state.ma.us/dem/programs/forestry).

Table 13. Number of licensed private consulting foresters in LWP communities.

City or Town	Total
Amherst	2
Belchertown	4
Brimfield	1
Brookfield	1
Fitchburg	1
Granby	1
Hubbardston	1
Orange	1
Palmer	1
Paxton	1
Pelham	1
Petersham	1
Princeton	3
Shutesbury	3
Sturbridge	1
Wendell	1
Westminster	2
Worcester	1
Grand Total	27

- *Maple sugar producers*

There are 12 sugarhouses listed within this ecoregion (Table 14) and as members of the Massachusetts Maple Producers Association (www.massmaple.org). Within this ecoregion, the town of Sturbridge has the greatest concentration of sugarhouses (3). All but one of these sugarhouses burns wood to boil its sap.

Table 14. Maple sugar producers in LWP communities.

Maple sugar producers	
Town or City	Total
Belchertown	1
Granby	1
Hardwick	1
Leverett	1
Montague	1
North Brookfield	1
Orange	2
Sturbridge	3
Wendell	1
Grand Total	12

- *Christmas tree growers*

Christmas tree growers in this ecoregion produce Christmas trees as well as roping and accessories for retail and/or wholesale markets. There are eight Christmas tree growers listed in the online directory of the Massachusetts Christmas Tree Association (http://www.Christmas-Trees.org) and located within this ecoregion (Table 15).

Table 15. Christmas tree growers in LWP communities.

Christmas Tree Growers	
Town or City	Total
Amherst	1
Auburn	2
Belchertown	1
Monson	1
Paxton	1
Sterling	1
Wilbraham	1
Grand Total	8

Despite this significant contribution to the local economy, a substantial amount of the forest products generated in the ecoregion are exported. Conversely, many of the wood and other forest products sold and used in the region are imported. For example, in 2001, Massachusetts purchased more than $745 million worth of forest products from Canada (http://www.canadianembassy.org/2002/ma-en.asp)

Spiritual Values

Finally, forest ecosystems have cultural and spiritual values that may defy quantification, but are still very important since they influence public opinions and decisions regarding the management of those forests. The large blocks of undeveloped and relatively unbroken mature forest cover in the LWP ecoregion undoubtedly provide a source of personal and spiritual renewal for many residents. Oftentimes, this value of natural areas goes unrecognized until management or development activities alter those areas.

Cultural Resource Protection

Cultural resources are the evidence of human history including prehistoric and historic archaeological sites, buildings, structures and landscapes. They are fragile and non-renewable. Once destroyed, they are gone forever. Similar to endangered and threatened species of flora and fauna, the fragility of these resources places a value on them that is difficult to calculate.

Concerned over the increasing loss of cultural resources to development, neglect and natural forces, State and federal legislators have created a body of preservation legislation spanning over 35 years. With these laws in place, future generations will have the opportunity to experience significant places as a way to understand, appreciate, and learn about the past. It is incumbent upon EOEA land managers to locate and assess the condition of both historic and prehistoric cultural resources and to generate plans for protecting unique and significant resources.

- *Prehistoric Archaeological Sites*

In 1984-85, the Massachusetts Historical Commission (MHC), as part of a statewide historic resource inventory that was partially funded by the National Park Service, studied the sixty towns and cities that comprise Worcester County, as well as the Middlesex County towns of Ashby and Townsend. The MHC survey resulted in the publication of a report entitled ***Historic and Archaeological Resources of Central Massachusetts*** (MHC 1985). The MHC also inventoried 69 towns and cities in Hampden Hampshire and Franklin counties, the results of which were published in ***Historic and Archaeological Resources of the Connecticut Valley*** (MHC 1986) Although the MHC's study areas do not coincide with EOEA's Lower Worcester Plateau Ecoregion, combined they provide a convenient framework for evaluating the potential existence and significance of the cultural resources on the 681,000 acres that comprise the Lower Worcester Plateau Ecoregion, and for formulating a plan for their protection.

A preliminary inventory reveals that over 450 prehistoric sites are recorded in the files of the State Historic Preservation Officer at the Massachusetts Historical Commission. While conducting the statewide Inventory of Historic and Archaeological Resources noted above the MHC determined that its records contained only a fraction of the sites that were actually known to local amateur archaeologists and artifact collectors statewide. Therefore, we anticipate that many more prehistoric sites than are recorded actually exist within the Lower Worcester Plateau Ecoregion.

The Lower Worcester Plateau is well endowed with fresh water sources including an extensive network of wetlands, ponds, lakes and small streams. Several important river systems drain the ecoregion: Chicopee, Blackstone, Nashua, Millers, Ware, Quinebaug, and French. This patchwork of waterways provided the local prehistoric populations with ample subsistence resources throughout prehistoric times.

The existing archaeological record indicates that by 12,000 years ago Paleo Indian hunters and gatherers had occupied the margins of Glacial Lake Hitchcock in what today is largely defined as the Connecticut River Valley. Several Lower Worcester Plateau Ecoregion towns lie within, or are adjacent to this former lake, and they have yielded evidence of Paleo occupation. A short distance to the east, the former Swift River with its East and West branches, attracted Paleo hunters also. Throughout the Lower Worcester Plateau Native American occupation continued without a break, albeit on a seasonal basis, until early historic times. Every cultural/temporal period of prehistory is represented throughout the region, spanning a period from about 12,000 ago to the late 1600s: Paleo, Early, Middle and Late Archaic, Early, Middle and Late Woodland and Early Historic.

There are several environmental factors that made the Lower Worcester Plateau Ecoregion so appealing during prehistoric times:

1. For those groups living towards the eastern portion of the Plateau the nearly inexhaustible resources of the coastal zone, particularly estuaries, were well within their summer exploitation territories.
2. For those groups living towards the western portion of the Plateau the diverse and abundant resources of the Connecticut River were easily accessible.
3. The Chicopee Drainage seems to have been particularly important as clusters of sites on the former Swift and Quaboag Rivers suggest that they were core areas of settlement. Other regional cores developed in the Sterling/Leominster, Worcester/Holden and Charlton/Oxford regions.
4. From about 8,000 years ago, the many falls and rapids in the principal river drainages in the ecoregion (Chicopee, Quinebaug, French, Blackstone and Nashua) served as fishing stations where anadromous species could be harvested on their spring spawning runs.
5. Expanses of riverine meadows within the various river drainages of the ecoregion provided excellent habitat for a wide variety of resident fauna that were important for subsistence purposes.
6. The maze of ponds, lakes and wetlands provided adequate subsistence resources and cover during the fall and winter months.
7. The rich alluvial deposits along the various larger rivers in the ecoregion were favored by the Woodland horticulturalists from 3,000 to 450 years ago.
8. In the entire Lower Worcester Plateau Ecoregion, only the Millers River appears to have offered less than maximum resource opportunities throughout prehistory. Due to the

rugged terrain and often steep sided ravines through which the Millers traverses occupation here was low, but site frequencies are high enough to attest to human presence here.

It is important to note that at no time in prehistory did humans randomly roam across the landscape. Instead, their lifeways were driven by a keen knowledge of their natural surroundings; there was considerable purpose to their actions and activities. Since this behavior was recurrent and patterned, archaeologists have been able to quantify the underlying characteristics of where prehistoric hunters and gatherers choose to live i.e., archaeological site locations, and they have developed a model based on ***Site Location Criteria.*** The use of Site Location Criteria is a valuable tool for land managers in assessing the potential presence of archaeological sites, and therefore the potential of adversely impacting sites by any proposed undertaking that involves ground modifications or subsurface disturbances. As EOEA agencies develop Forestry Management Plans the use of Site Location Criteria and consultation with professional archaeologists will become increasingly important (see the Issues, Goals and Opportunities section).

- *Historic Archaeological sites*

During the 17th century sections of Brimfield, the Brookfields, Sturbridge, Holland and Wales are believed to have developed into a principal core area of settlement for the Quaboags, a sub-group of the Nipmucks. A Native American palisaded encampment reputedly existed on Sherman Pond in Brimfield.

Historically, a network of Native American trails crisscrossed the area, with the major trails tending to follow the courses of the major rivers within the ecoregion. They ran primarily east west, toward the Connecticut Valley, and or the coastal lowlands. A system of lesser trails penetrated the upland areas as well following the networks of tributary streams. During the Colonial Period (1675 – 1775) and Federal Period (1775 – 1830) many of these Native trails became important roads for the slowly growing population. The Bay Path, which ran from Boston to Springfield and through the Berkshires to New York, is the best known of these.

Scattered throughout the Lower Worcester Plateau ecoregion are several thousand of Historic Archaeological sites stemming from 18th and 19th century saw, grist and textile mill operations. More numerous, but not necessarily more visible, are the archaeological remains farmsteads, with the cellar holes of the main houses, barns and out buildings. In the Quabbin Reservation alone an Archaeological Inventory performed between 1994 – 1998 recorded over 900 historic sites. Granted, the unusual circumstances surrounding the damming of the Swift River and the construction of the Quabbin Reservoir, which necessitated the disincorporation of Enfield, Dana, Greenwich and Prescott is largely responsible for such an unusual site frequency. At the same time much of this land was rocky and hilly with unproductive soils yet agriculture remained one of the mainstays of the economy though historic times. This paradox suggests that the potential for historic archaeological is very high in areas with more favorable environmental and soil conditions.

- *Historic Landscapes*

A number of specific areas within the Lower Worcester Plateau Ecoregion have been identified in the ***Massachusetts Landscape Inventory*** (DEM 1982).This study listed the following landscapes as distinctive and significant because of their: wilderness character with heavily wooded mountains and hills, waterscapes and abundant and varied wildlife (Quabbin Unit), outstanding scenic and agricultural landscapes (Sterling Unit), rugged scenery with old farmsteads and large reservoirs (Mt. Wachusett Unit), finest pastoral scenery east of the Connecticut Valley (Dudley – Charlton Unit), relatively unspoiled, open hill town (Grafton Unit), upland areas with some farmland and excellent vistas along the Shrewsbury Ridge (Upper Nashua Valley Shrewsbury Ridge Unit).

Small town centers and agricultural landscapes are abundant in this region. Most of the region remained rural and featured a dispersed settlement pattern throughout most of historic times. The archaeological remains of farmsteads and stonewalls that are scattered throughout the ecoregion together with the surviving stock of operating farms attest to the resilient nature of 18th, 19th and 20th century farmers who made a living in this interior upland region, often on somewhat marginal land. These same remains - stonewalls that partitioned off land for pasture and tillage, the archaeological remains of many former farms and mills, together with those still in operation - create significant ***vernacular landscapes*** of considerable importance to the Lower Worcester Plateau region and to the Commonwealth in general. Likewise, the combination of these vernacular landscapes and the varied topography create a collection of ***Scenic Landscapes*** that are unique and important to retain.

- *National and State Register Resources*

Within the 51 communities in the Lower Worcester Plateau Ecoregion, there are about 537 listings on the State Register of Historic Places, representing in excess of 1500 properties. Listings include single buildings and structures, as well as historic districts which may contain multiple resources such as buildings, landscapes and structures. Each listing reflects a valuable part of the Commonwealth's history and can range from a single 18th century milepost and individual farmsteads to mill and factory buildings, worker tenements and public buildings. The Ecoregion is also host to 19th century state hospitals and a major portion of the infrastructure for the water supply system for metropolitan Boston.

The State Register is the best source of data for historic properties in the Commonwealth's cities and towns. However, the State Register does not always include information on properties owned by the state, such as institutions, recreational facilities and wildlife management areas. There are twenty eight DCR facilities within the LWP Ecoregion, many of which are likely to contain historic resources such as stone walls, buildings, roads and structures. The DCR Cultural Resource Inventory (CRI) is a baseline survey of known and potential resources within those parklands. According to the CRI, there are over 200 historic sites listed in the inventory for the DCR facilities in the region. Since the inventory is not a complete record, a more comprehensive inventory would be needed to generate specific recommendations for the preservation of significant sites. The Department of Fish & Game has over 40 properties within the ecoregion for which there is no inventory of cultural resources.